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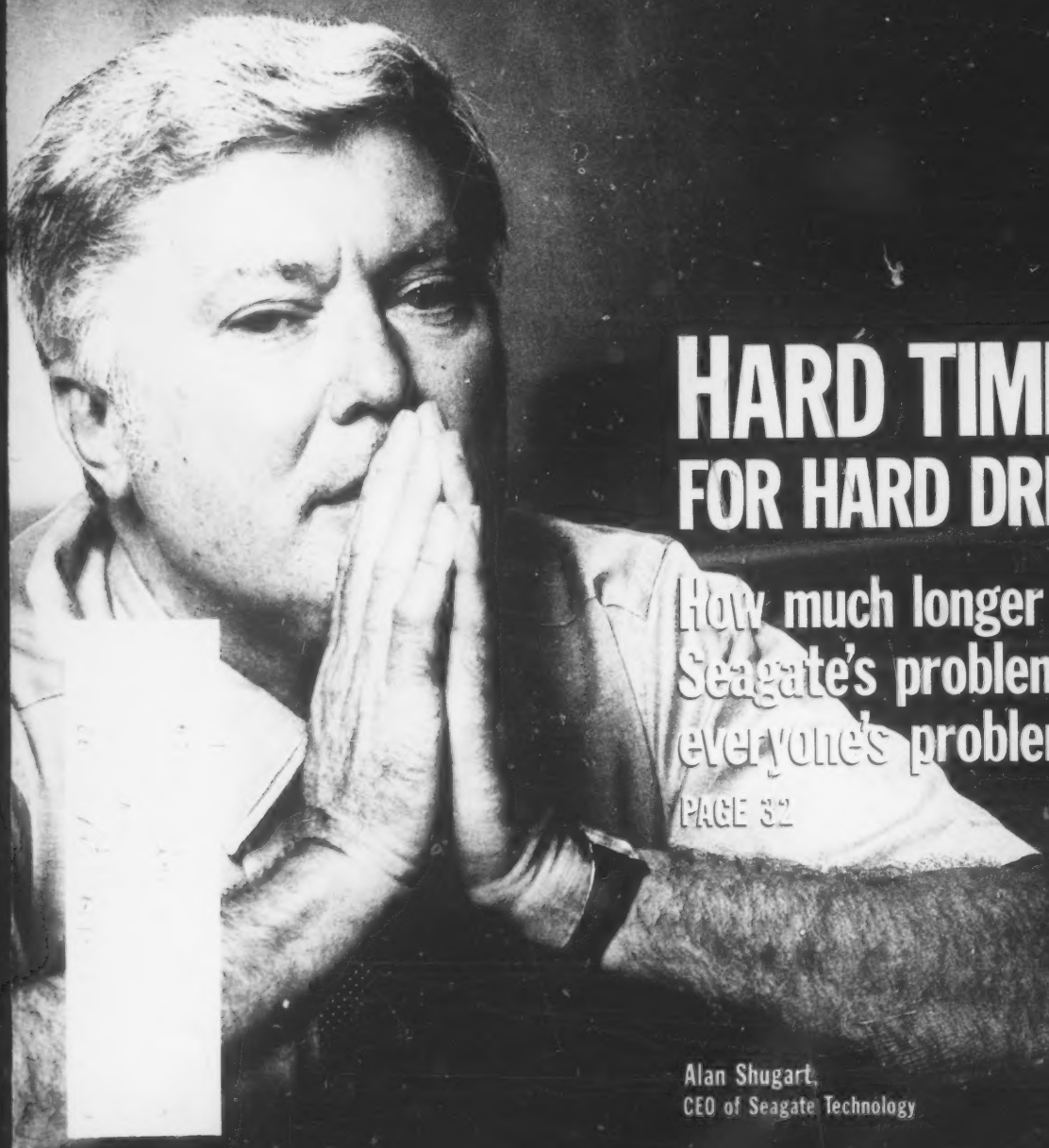
FOR MANAGEMENT IN ELECTRONICS, COMPUTER & SYSTEMS COMPANIES—WORLDWIDE

NOVEMBER 15, 1988



HARD TIMES FOR HARD DRIVES

How much longer will Seagate's problems be everyone's problems?

PAGE 32

Alan Shugart,
CEO of Seagate Technology

Why IC production gear must be more reliable PAGE 104

3Com and Bridge make marketing work PAGE 54

Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES – WORLDWIDE

VOL. 14, NO. 22 NOVEMBER 15, 1988

PAGE 32 "Price wars don't bother me," says Seagate's chairman and CEO Al Shugart

Cover Story/Strategies

TRADE

32 Hard times for hard drives

Because of its sheer size, Seagate dominates the PC hard disk drive industry. But excess inventory at the company has led to a slashing of production, and anxiety in the industry that a price war might erupt. Is overproduction an industry-wide problem, or did Seagate not react quickly enough to marketplace changes?

Business Trends

TRADE

16 Trade bill gives U.S. electronics firms a weapon

Despite a good bit of early opposition from the Reagan administration, the law passed by Congress authorizes a get-tough approach on trade.

OPTICAL COMPONENTS

20 Why opto makers are picking up the datacom call

As long-line business levels off, optoelectronic parts makers see money in datacom and subscriber-loop telecom.

SEMICONDUCTORS

24 Beam us in: Chip makers vie to control laser printers

Laser printer controllers already mean $250 million to IC firms. But should they peddle generic or special chips?

Strategies

DISK DRIVES

32 Hard times for hard drives

Because of its sheer size, Seagate dominates the PC hard disk drive industry. But is that power waning?

FINANCE

42 Since Black Monday, the spotlight's been on ROI

Suddenly, investors are concerned. And when Wall Street talks, everyone listens. High-technology firms like Cray and Compaq are focusing on ROI and ROE as well.

- Top ROI performers

COMPUTER NETWORKS

54 Sales and profit gains ease the pain of 3Com/Bridge merger

Clashing management styles and sales philosophies made it a difficult transition year for the networking firms. But the integration appears to be a success.

TELECOMMUNICATIONS

62 The bigger, the better, says Alcatel chairman Suard

Only giant telecom companies will survive a shakeout in switching, says Suard. And his French firm expects to be one of less than 10 that make it.

Asia/Pacific Business

COMPUTERS

72 Is Japan's Fifth-Generation project a flop?

Yes, if judged on much-promised technology breakthroughs, say U.S. critics. But by sticking to applied R&D, it may yield fast commercial spin-offs.

SEMICONDUCTORS

78 Making semiconductors in the land Down Under

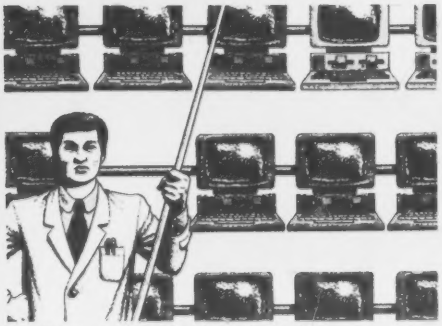
AWA MicroElectronics will commence ASIC manufacturing in Australia next month. Should Motorola, National Semiconductor and TI be concerned?

Cover photograph: Liane Enkelis

PAGE 16 The trade bill becomes law: Rep. Dan Rostenkowski, Sen. Lloyd Bentsen and Rep. Richard Gephardt

PAGE 84 Why defense firms fret over the Pentagon's Strategic Computing Program

PAGE 116 DEC's David Streeter: Companies don't want to incur site clean-up costs



PAGE 72 Is Japan's Fifth-Generation project a flop?

PAGE 42 High-tech firms focus on ROI. Industry leader Cray Research's CFO John Carlson

Market Perspectives

DEFENSE RESEARCH

84 Why defense firms fret over the Pentagon's computer R&D

DOD budget cuts and DARPA's new passion for pure research may mean that the Strategic Computing Program lacks the commercial punch it once promised.

AUTOMOTIVE ELECTRONICS

94 Throw out the road atlas; here comes the digital map

"Cooperative" highways soon will communicate with "smart" cars to tell drivers where to go. And electronics is paving the way.

SEMICONDUCTOR PRODUCTION

104 Issues for the '90s: Reliability and support

The push to submicron geometries may be putting a financial strain on equipment suppliers, making it harder for start-ups to compete.

Sites & Facilities

REAL ESTATE ASSETS

114 Savvy facilities planners see profits in land deals

Electronics managers haven't been known for their real estate prowess. But now they're starting to see the earnings potential.

HAZARDOUS WASTES

116 Toxic waste poisons the soil—and property deals

Anyone acquiring property must pay to clean up previous contamination. The cost can make a buyer skittish.

DIRECTORY

122 U.S. directory of plant sites and facilities

Business Barometer

INDUSTRY FORECASTS AND INDEXES

152 **Active component prices**

IC price pressures, especially for DRAMS, are finally stabilizing.

154 **Plant utilization**

Factory operating rates may have reached their peak.

Departments

5 **Inside Business**

9 **Letters**

11 **Upstarts**

ASIX Systems, Maximum Storage, Network Computing Devices

135 **Comment**

A field guide for hiring start-up staff from management consultant, Richard Stein

140 **Executive Viewpoint**

How ATE suppliers can cut their customers' high cost of test, by Steven Bisset, president of VLSI test equipment maker Megatest

146 **Coming Attractions**

149 **My View**

The wedding. Dancing. And fun

156 **Viewpoint**

Opportunities for women managers

Companies in this Issue

146 **An index of the companies covered in this issue.**

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REPRINTS

ELECTRONIC BUSINESS articles are available on a custom printing basis at reasonable prices. Contact Joanne Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E. Touhy Ave., P.O. Box 5080, Des Plaines, Ill. 60018 (312) 635-8800

Slipped disks

A decade ago, who'd have believed that the hard disk drive market would become the knee-in-the-groin, price-pricked commodity business it is today? And who'd have thought that Seagate Technology — former owner of two-thirds of the world's 5.25-inch hard disk drive production and longtime maker of magnificent profits — would be wading around in the red stuff?

Watching the frowns deepening not only in Scotts Valley but throughout the drive business, senior editor Alden Hayashi headed west to explore Seagate's problems, and to try to anticipate how much longer those difficulties would be shared by the rest of the industry.

He returned with a thorough analysis of an industry in turmoil, an industry which still finds it cannot gloat over the disk drive king's misfortunes. Seagate may hold prisoner "only" 55% of the 5.25-inch business these days, but that's plenty influential still. Just watch how Wall Street responds: when Seagate catches a stock-market cold, the entire industry sneezes.

But Alden found plenty of evidence to show that Seagate's grip may be loosening. Stuck with a vertically integrated structure it believes gives it quality, price and parts-sourcing advantages, the company may now be too earthbound to dash after fast-moving opportunity in 3.5-inch drives. And it may have misjudged an industry shift to OEM sales, where performance is valued as highly as price. What should computer makers, distributors, drive makers and VARs do next? Our cover story should help them decide.

Seagate sleuth Alden Hayashi

Forget profits?

Forget net income. Well, don't exactly forget it, but give it less status in the hierarchy of crucial financial measures. Today, reports contributing editor Ray Wise, return on investment (ROI) is the yardstick that investors increasingly prefer. Ray's article supports the "Top ROI performers" directory assembled by senior editor Linda Stallmann. Cray Research comes out tops: with an ROI last year of 20.2%, the supercomputer maker clearly has a management team that is deploying corporate assets and preserving shareholder values more efficiently than most

JOHN KERR, Managing editor

ELECTRONIC BUSINESS® (ISSN 0163-6197) is published semi-monthly, except monthly in December, by The Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M. McDermott, President; Frank Sibley, Group Vice President; Jerry D. Neth, Vice President/Publishing Operations; J.J. Walsh, Financial Vice President/Magazine Division; Thomas J. Dellamaria, Vice President/Production and Manufacturing. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5800. Telephone: (303)388-4511. Second-class postage paid at Denver, CO 80206-5800 and additional mailing offices. POSTMASTER: Send address corrections to ELECTRONIC BUSINESS® at the Denver address. ELECTRONIC BUSINESS® copyright 1988 by Reed Publishing USA; Saul Goldweitz, Chairman, Ronald G. Segel, President/C.E.O.; Robert L. Krakoff, Executive Vice President; William M. Platt, Senior Vice President. Annual subscription rates for non-qualified people: USA/Canada/Mexico, $55 per year; other countries, $85 per year (including air freight), $170 per year for air mail. Except for special issues where price changes are indicated, single copies of regular issues are available for $6.00, $8.00 and $10.00 (USA, Canada/Mexico and foreign). Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5800. Cahners Publishing Company, A Division of Reed Publishing USA • Specialized Business Magazines for Building & Construction • Manufacturing • Foodservice & Lodging • Electronics & Computers • Interior Design • Printing • Publishing • Industrial Research & Technology • Health Care • Entertainment. Specialized Consumer Magazines: American Baby • Modern Bride.

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Hard times for hard drives

Because of its sheer size, Seagate dominates the PC hard disk drive industry. But is that power waning?

BY ALDEN M. HAYASHI

These are tough times for Seagate Technology, the world's largest manufacturer of hard disk drives for personal computers.

After borrowing $290 million to expand manufacturing last year, the company was later forced to slash production by a third. Two hundred workers were axed from the Scotts Valley, Calif., headquarters last summer. And, on Oct. 25, Seagate announced it had lost a staggering $52.8 million during its Sept. quarter. The news stunned Wall St. analysts. This, after the company's stock price had plunged 50% since July.

Seagate's recent woes, however, have not given competitors cause for celebration. Instead, everyone is nervously awaiting the company's next moves. Like a wounded grizzly bear, Seagate is massive, powerful and dangerous; it could drag the entire industry down, fear pessimists. "Every time Seagate hiccups, you end up with perturbations everywhere," notes Kathy Braun, vice president and general manager of storage products for Western Digital Corp. of Irvine, Calif.

Stirring widespread anxiety is the possibility that Seagate might incite a price war that could engulf the industry. Furthermore, in the eyes of stock investors, Seagate's problems are the industry's problems. Consequently, when Seagate stumbles, it often touches off a chain reaction on Wall Street that winds up cheapening not only Seagate's stock, but competitors' stocks as well.

But Seagate's influence over the industry might be dwindling as the hard disk drive market undergoes some fundamental changes. Competitors assert that more and more sales are being made directly to computer manufacturers as opposed to distribution and dealer networks where Seagate — with its high-volume, low-cost manufacturing strategy — dominates. And others cite Seagate's slowness to tackle the fast-growing 3.5-inch drive sector as evidence of its waning power.

Not a one-quarter fix

What frightens many competitors today is Seagate's massive inventory problem. At the end of the company's fiscal year, ended this past June, total inventory had swelled to $365 million, a 169% increase over the previous year's figure. Meanwhile, the company's cash dropped from $396 million to $93 million. Referring to the situation, Alan F. Shugart, Seagate chairman and CEO, says, "It's not going to be a one-quarter fix. . . . Hopefully we can do it in two. But maybe it'll take three."

Excess inventory is only the tip of Seagate's iceberg. The company has more than a million square feet of manufacturing space that, if not kept busy, aggravates overhead costs. "We *have* to get our production rates back to where they were," declares Shugart. "We recently had to reduce our production rates, which increased our costs. That's what's hurting us."

Accordingly, Shugart says, "We're planning on selling 7 million disk drives this fiscal year." Last calendar year, Seagate made 3.5 million drives, accounting for roughly 34.9% of total worldwide production (including captive facilities), according to market research firm Dataquest Inc. of San Jose. Shugart is counting on the worldwide market growing 40% to 45% this fiscal year.

Still, even assuming such robust demand, trouble lies ahead, asserts Phil Devin, Dataquest analyst. Devin predicts the worldwide demand for small hard disk drives will reach roughly 14.7 million units this year. The industry, however, has the capacity to produce 17 million such drives. Meanwhile, any slowing of growth in the PC market would exacerbate matters. In fact, it could spell disaster for many disk drive makers, agree analysts. "The drive industry could actually be faced with major plant write-offs, semiconductor style," warns John T. Rossi, of Alex.

Liane Enkelis

Brown & Sons in San Francisco.

The implications are clear, especially for those familiar with Seagate's hardball tactics. "Sure I'm concerned about a price war," says an executive at Longmont, Colo., drive maker MiniScribe Corp. "Seagate doesn't care what happens to their short-term margins."

Shugart has done little to allay those fears. "Price wars don't bother me," he flatly states. Although Shugart refuses to divulge his pricing plans, he does say: "If we have inventory, we have to do something about it." He asserts that because of Seagate's high-volume, low-cost manufacturing, the company is well armored to withstand any pricing wars.

Inordinate clout

Indeed, Seagate's sheer size affords the company inordinate pricing clout. "When Seagate lowers its prices, we *have* to respond. After all, it is an elastic market," grumbles David Dury, president for Priam Corp., of San Jose.

Seagate, certainly, is no stranger to pricing skirmishes. According to various accounts, the company in the past slashed prices on half-height 20- and 30-megabyte 5.25-inch disk drives, forcing competitors out of those markets. Early last summer, the company did the same with 85MB 5.25-inch products, painfully lowering unit prices to $500, from the $600 to $700 range. "Seagate has been cutting prices like crazy, holding people's hands to the flier," notes Rossi of Alex. Brown & Sons.

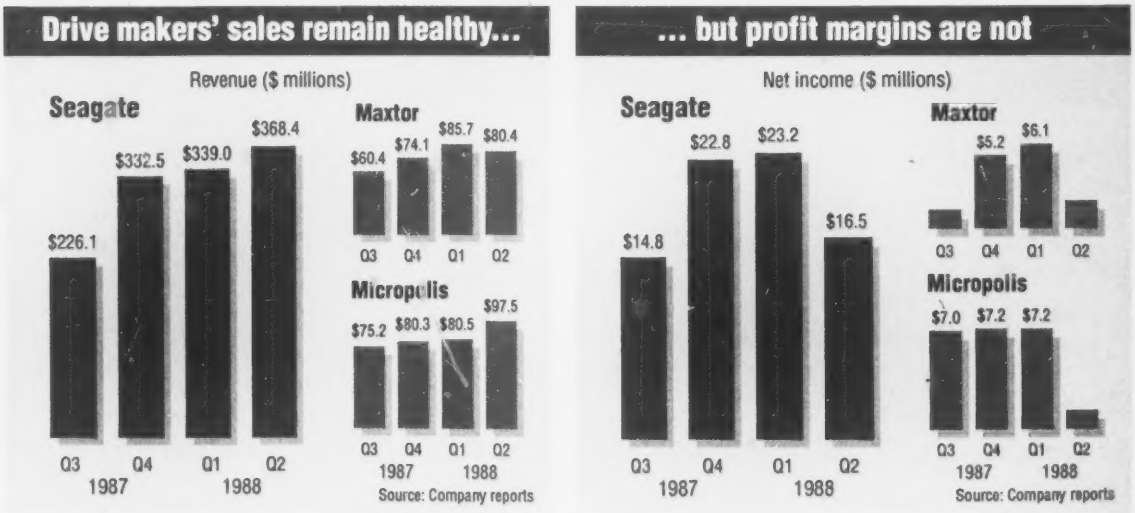
Already, the damage has been substantial. Of the flock of disk drive makers, one of the hardest hit was Maxtor Corp. of San Jose. "We did an analysis — taking the difference between our March and June prices — and that was essentially the entire cause of the decrease in our gross margins from about 29% to about 21%," asserts Maxtor president George M. Scalise. At MiniScribe, margins slid 5%. Micropolis Corp. of Chatsworth, Calif., blames the pricing scuffle for a drop in net income which, according to one Wall Street analyst, will plunge from $27 million last year to $14 million this year. Seagate itself has not been immune. The company's gross profit margin fell to 19% last fiscal year, from 29% the previous year.

Last year, Seagate made 3.5 million drives, or 34.9% of total worldwide production

Not surprisingly, competitors are avoiding head-on collisions with Seagate, particularly in the behemoth's hometown playing field, the so-called personal computer "aftermarket." In these market channels, instead of shipping disk drives to computer makers such as IBM and Apple Computer Inc., independent drive companies like Seagate sell their products elsewhere, generally to distributors and dealers who then combine the drives with PCs bought separately from the computer makers.

"If I was operating in that market right now, I would be very, very concerned. There's no doubt about it that Seagate's going to be calling the cadence on this one for quite awhile," says Timothy Mahoney, vice president for sales and marketing for drive maker Rodime Plc, headquartered in Scotland.

As a result, Micropolis, MiniScribe and Quantum Corp., among others, have turned their attention to selling disk drives directly to the computer makers, or OEMs, instead of through the aftermarket where distributors and dealers worship prices supreme. "We were forced to focus on OEM relationships," says David Brown, Quantum president. Adds Stuart P. Mabon, chairman and president of Micropolis, "We are no longer pursuing the 85MB 5.25-inch aftermarket. We decided that there wasn't any point in giving disk drives away." In



Price skirmishes and overcapacities have already eroded the margins of some hard disk drive companies

fact, when asked how a company like Micropolis competes against a giant like Seagate, Mabon replies: "We now compete with Seagate in only 5% of our business. That's how we compete against Seagate."

A different ball game

Unlike the aftermarket, selling to OEMs is a whole different ball game, one in which Seagate may not be adequately equipped to compete, allege the company's critics. For starters, OEMs generally require state-of-the-art products, historically not one of Seagate's strengths. "Seagate tends to use yesterday's technology in huge volumes," says Micropolis' Mabon. "The OEM customer is not going to stay with you if you don't have a product that meets his requirements, no matter *what* you price it for," asserts Finis Conner, chairman and CEO of Conner Peripherals Inc. of San Jose.

So competitors have scampered upmarket to faster disk drives with smarter interfaces and higher capacities. In addition, most companies are focusing their efforts on making smaller drives using the newer 3.5-inch format.

But pricing wars, like brush fires, can often spread uncontrollably, engulfing territories far beyond their initial reach. "Seagate does establish a price-point reference that we have to recognize in the marketplace, because our customers recognize it," admits Priam's Dury. "You can't have a 50MB product selling for $500 and expect to sell a 100MB for $4,000. That's just too much more for the extra capacity." Maxtor's Scalise reports that the recent pricing pressure on 85MB 5.25-inch drives has affected practically his entire 5.25-inch line, including 760MB products. Western Digital's Braun says she is even expecting some price degradation in the low end of her 3.5-inch line.

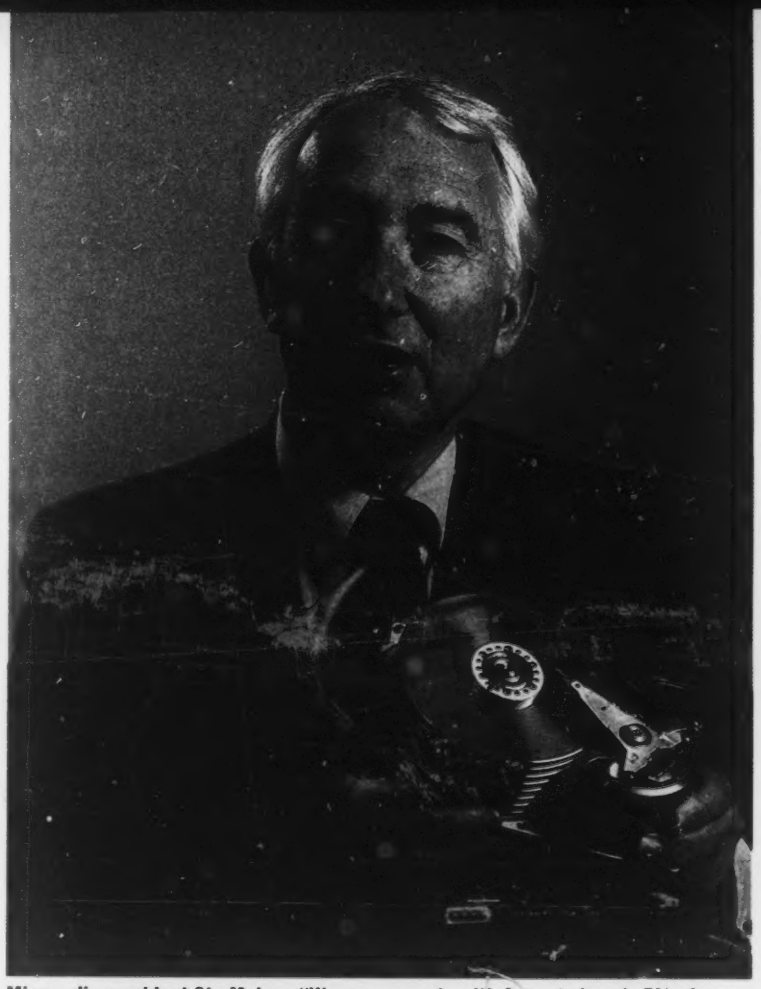
Seagate's sins

Competitors also complain that Wall Street, which thinks of Seagate and the disk drive industry as being one and the same, tends to punish everyone for Seagate's sins. "That's the biggest effect on us by Seagate," declares Conner of Conner Peripherals, which made its debut on the stock market last April.

Conner and other industry executives complain that when Seagate's stock drops, so does theirs, regardless of how well they're doing. Last July 20, Seagate's stock tumbled 29.7% after the company released its quarterly results which disappointed Wall Street. For no apparent reason, Conner Peripherals' stock fell 6.5% that day. Maxtor's dropped 5.3% and both Micropolis and MiniScribe saw their stocks fall 4.8% [see chart].

Seagate's troubles can even overshadow a competitor's announcement of a plum contract. "I can't fathom how an analyst can write a glowing report on a new, leading-edge computer from a major computer manufacturer without looking back at who's supplying the key components and writing a consistent report on that," grouses Conner.

If Seagate's influence over the hard disk drive industry is strong today, it was almost monopolistic several years ago. In 1981, the company accounted for roughly two-thirds of the world's production of 5.25-inch drives, according to Disk/Trend Inc. of Mountain View, Calif. At that time, Seagate's strategies were closely scrutinized by competitors. "We all manufacture in the Far East now. We learned that lesson from Seagate," says Rodime's Mahoney. But Seagate no longer wields such power. The adjective "Seagate compatible," coined when the company established its ST506 5.25-inch disk drive as the industry standard years ago, is rarely used today.



Micropolis president Stu Mabon: "We now compete with Seagate in only 5% of our business. That's how we compete against Seagate"

Michael Grecco

A shrinking aftermarket?

Meanwhile, Seagate's slip, allege critics, was due to the company's failure to react quickly enough to marketplace changes. For starters, the aftermarket's relative size may be shrinking, assert some industry watchers. Five years ago, only one out of every four PCs shipped by OEMs had a hard disk drive already installed. At the same time, the other three had floppy drives which left a tremendous opportunity for distributors and dealers to add hard versions by buying them from independent

manufacturers such as Seagate.

Today, however, computer OEMs are intent on grabbing the hard drive sales for themselves, contend analysts. IBM, for example, has announced that 90% of its new Personal System/2 computers will be shipped already equipped with a rigid drive, which will leave little opportunity in the aftermarket, asserts Dataquest's Devin. Consequently, Devin argues that disk drive makers must now deal directly with computer companies.

Shugart denies that such a fundamental change is occurring in the marketplace. According to him, two-thirds of Seagate's sales are still being made to the aftermarket. "It might bounce around a percentage point or two each quarter, but in general, it's stayed about the same," he insists. Dataquest's Devin predicts the aftermarket will shrink from 47% of the total 5.25-inch market this year, to 32% in 1992.

Seagate doesn't have the right products to compete for OEM contracts, claims Conner of Conner Peripherals, where virtually all sales are to OEM customers. "Ninety percent of Seagate's shipments are in older technologies," he scoffs. Apparently, Conner Peripherals' products — fast 3.5-inch drives — are the right ones: thanks to a major contract from Compaq Computer Corp., which also invested in the start-up, first-year sales at Conner Peripherals rocketed past $100 million.

"The major issue right now is what Seagate can do with 3.5-inch drives because the industry is heading in that direction," says Rossi of Alex. Brown & Sons. Dataquest's Devin asserts that 3.5-inch drives will account for 54% of the 14.7 million units made this year. Seagate, however, had only shipped 207,000 such drives, less than 10% of the company's total production, during the first half of 1988, admits Shugart.

"Seagate is at least a year behind in making the transfer to 3.5-inch drives," asserts Bob Katzive, analyst for Disk/Trend. A common criticism fired against Seagate is that the company's delay in ramping up 3.5-inch drive production resulted in missed sales targets. Not true, contends Shugart. Referring to the June quarter when Seagate's financials began faltering, he says, "We were not supply constrained on our 3.5-inch drives. We were demand constrained."

Some say Seagate may be at least a year behind in switching to 3.5-inch drives

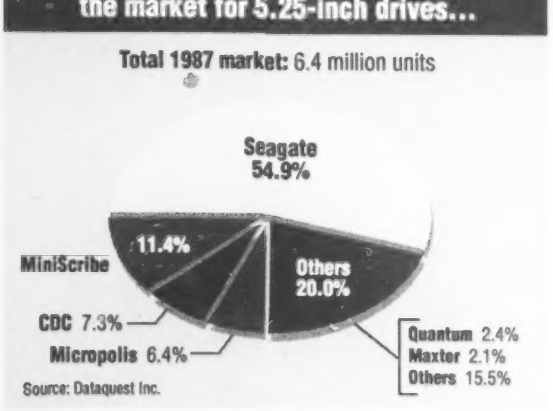
Rodime's Mahoney gives his explanation of the apparent discrepancy: "Seagate wasn't supply constrained because they had the wrong products." Mahoney insists that the market wants faster drives with smarter interfaces. "The fact that Seagate can build a drive cheaper than anybody in the world doesn't mean anything if it's the wrong drive," he asserts.

Upgrading its drive technology will prove a daunting task for Seagate because of the company's manufacturing emphasis on vertical integration. Years ago, Seagate decided to make practically every disk drive part by itself, including thin-film disks, recording heads, drive motors and semiconductors. The company did so in order to assure itself of an adequate supply of parts. Because of Seagate's huge production volumes, the strategy made sense. And vertical integration worked well in the distributor and dealer aftermarket, where product lifespans were long.

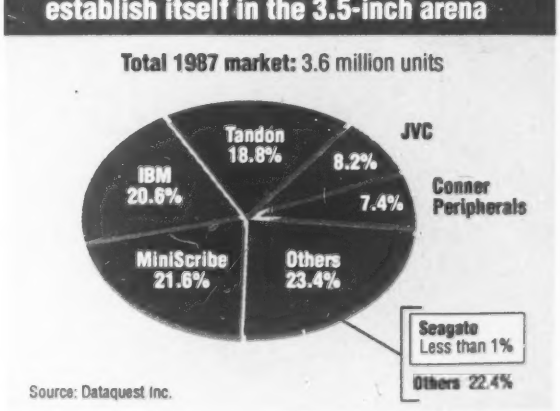
However, in the OEM marketplace, where product designs come and go like Gucci fashions, vertical integration suddenly becomes a disadvantage, assert critics. "Vertical integration, if not a practical barrier, is an emotional one to rapid product transitions because if you bring out a new product that obsoletes your old one, it requires a whole new capital structure," says Conner, who speaks from experience. Before founding Conner Peripherals, Conner was vice chairman for Seagate and also served a short stint at drive firm Computer Memories Inc., now headquartered in Far Hills, N.J. Adds Quantum's Brown: "Because Seagate ends up having to redesign all of the components, vertical integration could become the company's albatross."

Be that as it may, Seagate is not nearly as vertically integrated as outsiders think, counters Gunter Heine, general manager of the company's motor division. "We buy more motors and disks than we make," he as-

While Seagate dominates the market for 5.25-inch drives...



... the company has been slow to establish itself in the 3.5-inch arena



Seagate is not nearly as vertically integrated as outsiders think, says Gunter Heine, general manager of the company's motor division.

serts. In fact, Heine says Seagate makes less than 10% of the electronic components it needs.

Don't count on IBM

Seagate doesn't have forever to establish itself in the 3.5-inch market. Already 80% of the major OEM contracts for such drives have been locked up, asserts one source who claims that of the major U.S. PC manufacturers, only Wyse Technology of San Jose is open game.

AST Research Inc., Compaq and Zenith Electronics Corp. have chosen 3.5-inch drives from Conner Peripherals. Apple recently awarded Quantum with a contract for 40MB and 80MB 3.5-inchers. A subsidiary of N.V. Philips GL has chosen Rodime. Tandy Corp. decided to go with two suppliers, neither of which appears to be Seagate. Furthermore, IBM, which used to account for more than 50% of Seagate's sales, seems to have turned completely in house. This year, Big Blue will make more than 2 million 3.5-inch units in its Japanese facility, according to a Dataquest estimate.

And, as in any market that undergoes a fundamental shift in technology, a window has opened for new competitors. At least four California start-ups — Areal Technology Inc. of Santa Clara, Cardiff Peripherals Corp. of Carlsbad, Comport Corp. of Milpitas, and Kalok Corp. of Sunnyvale — have recently entered the marketplace. Three of the companies did so through manufacturing agreements with Korean partners.

Still, all is not lost for Seagate. "There's a new machine being designed in every one of these computer OEMs every day of the week, so the game is never won or lost. It's a continuing war, forever and ever," notes Western Digital's Braun. To be sure, Seagate is preparing itself for the next battle. "They've got some pretty spectacular 3.5-inch products in development," says Dataquest's Devin.

And Seagate shows no signs of backing down. After investing $300 million in capital expenditures last fiscal year, the company is planning to spend $150 million more this year. Given its fragile financial health, Seagate may have to fall further in debt. The company already issued $287 million of convertible debentures last year. "We have several lines of credit and we may have to expand those lines," says Shugart.

A go-for-broke style

The son of a conservative structural engineer, Shugart nonetheless has a definite go-for-broke management style. "Shugart looks, acts, and thinks like a wildcatter," says Rossi of Alex. Brown & Sons. "But if Shugart had been conservative, Seagate would be, at this point, just a $400 million company instead of the $1 billion company that it is."

Indeed, thanks to Shugart and David T. Mitchell, Seagate president and COO, sales skyrocketed from $215 million in fiscal 1985 to $1,265 million just three years later. Executive salaries have also soared. Last year, Shugart and Mitchell, along with Douglas K. Mahon, Seagate senior vice president, were among the electronics industry's top 10 highest-paid executives [ELECTRONIC BUSINESS Oct. 15, p74]. Each of the trio's salaries cleared the $1 million mark last year.

To justify those salaries, management will have to effect some major changes if Seagate is to succeed in the growing OEM marketplace, contend analysts. In addition to developing more innovative products, the company must become quicker and nimbler to keep up with the scorching pace set by OEM customers like Compaq. Says Quantum's Brown: "Seagate will have to become more like us, than us like Seagate."

Still, no one is dismissing the disk drive king yet. In fact, competitors are quick to express equal parts of both respect and fear for Seagate's resilient management. Indeed, only the impudent have forgotten how quickly the company resurrected itself after the PC market crashed in 1984. Even when sales plummeted from $344 million in fiscal 1984 to $215 million one year later, Shugart and Mitchell managed to maintain Seagate's profitability. Meanwhile, several other disk drive makers were wallowing in the red. Says Rodime's Mahoney: "How can you count Seagate out? My God, anybody who does is not being very smart." □

As Seagate goes...

Stock prices

	July 19, 1988	July 20, 1988	Percentage change
Seagate	18 1/2	13	-29.7%
Conner Peripherals	9 5/8	9	-6.5%
Maxtor	9 1/2	9	-5.3%
Micropolis	15 1/2	14 3/4	-4.8%
MiniScribe	12 7/8	12 1/4	-4.8%
Priam	1 5/8	1 3/4	+7.7%
Quantum	11	10 1/2	-4.5%

Source: NASDAQ

Last July 20, Seagate announced disappointing financial results for the June quarter, and the company's stock tumbled 29.7%. Apparently, the bad news also affected the stock prices of several competitors

Liane Enkelis

Since Black Monday, the spotlight's been on ROI

Suddenly, investors are concerned. And when Wall Street talks, everyone listens. High-technology firms like Cray and Compaq are focusing on ROI and ROE as well

BY RAY WISE

Generating high rates of return on investment can help a technology company keep growing and enhance the attractiveness of its shares, especially in a nervous stock market. And since October of 1987, the market has been nervous indeed. So, while investor concern over return on investment and equity appeared minimal during Wall Street's "trip to the moon on gossamer wings," these traditional measures have become increasingly important since that trip's disastrous end on Black Monday. "Investors are paying a lot more attention to such fundamentals as ROI and ROE," reports Rich Spillane, who runs the Fidelity Select Portfolio in Boston.

Last year, U.S. industry averaged a 10% return on investment. Even in technology, where returns tend to be above average, 20% is considered high. Yet, Minneapolis-based Cray Research Inc. produced an ROI of 20.2% in 1987 and 21.7% the previous year. Meanwhile, Compaq Computer Corp., with headquarters in Houston, last year boosted ROI to 24.8% from the year-earlier 16.7% and expects another 20%-plus performance this year. And Western Digital Corp., Irvine, Calif., attained a 20.3% ROI in 1987, a quantum leap from the year-earlier 13%. And leading software companies' ROIs hover around 30%.

A variety of factors can contribute to increased ROI. Finely honed forecasting techniques and careful capital marketing financing certainly help. Moreover, Cray is an example of one of the most important factors in keeping ROI high: product differentiation.

"Cray is the highest of high technology," says Warren K. Greene, president of the American Investors group of mutual funds in Greenwich, Conn. "Once you have reached that level, it is hard for anybody, even the Japanese, to catch you. Cray is in a world of its own."

While Cray's chief financial officer, John F. Carlson, does not shrug off the competition so readily, he generally agrees with Greene's assessment. "We are a single-product company with a clear vision," Carlson says. "Our products help customers do things they could not otherwise do. And to continue that product dominance, we spend 15% of revenues on research and development."

Product superiority can push up ROI because profitability reflects price, and price is driven by the product. Cray's supercomputers can simulate the effect of a wind tunnel in the design of an aircraft; test the durability of an auto without smashing it into a brick wall; and help oil companies find and recover petroleum deposits with maximum efficiency. Until now, it's been difficult for customers to find a cheaper model. Consequently, Cray has two-thirds of the worldwide supercomputer market, including an awesome 80% outside Japan. And the firm's machines fetch $2.5 million to $20 million each.

More than ever before, though, Cray is facing competition. In Japan, Hitachi Ltd. and NEC Corp. are making supercomputers, and Fujitsu Ltd. is also having a go at it. IBM would like to enter the market, Carlson says, but probably not the high end, which is Cray's exclusive turf. But Cray wants more volume in the middle because, according to Carlson, "it is questionable how much more the top end can grow."

ROI leader Cray Research Inc.'s CFO John Carlson: "We are a single product company with a clear vision"

Alvis Upitis

Another company benefiting from a high degree of product differentiation is Compaq Computer Corp, mainstay of the portable computer business and a big player in the IBM-compatible desktop market. Long term, company officials say, returns should be boosted even higher than the current high rates by a recently unveiled product at the high

end of the desktop computer line.

Compaq's high returns are the result of sound growth management, according to Daryl J. White, corporate controller. And that in turn, he says, is at least partially due to the company's deft timing of capital financings. Unless this cycle is finely tuned, a company can wind up with overcapitalization and excess capacity, or undercapitalization and too little capacity. Complicating matters are the vagaries of the capital markets and the necessity of responding swiftly when a market window opens.

Encountering a window in the bond market last spring, Compaq sold $200 million of 6.25% convertible debentures, raising its long-term debt to a highly respectable 25% of total capitalization. The capital structure of an average manufacturing company is 50% equity, 50% debt. Debt is cheaper than equity, says White, "and so you waste corporate resources by expanding with equity capital alone."

Compaq's growth has been dizzying recently, with 1988 sales expected to surge nearly 60% to $1.9 billion from last year's $1.2 billion — and this can cause problems. "When you are growing at such a rapid pace, in general, selling and administrative expenses can accelerate extremely fast," says White.

Another strong advocate of finely honed forecasting is Bert Moyer, CFO of Western Digital, whose sales of board-level subsystems and other products soared 66% last year and should jump a similar amount in 1988. "You have to forecast where your business is going," Moyer urges. "We like to keep our expansion a little short of our expectations." Moyer says some CFOs, to their eventual sorrow, seek to keep slightly ahead of demand. But then "only slightly" turns into "more than slightly."

Exacerbating this is the rapidly changing technology of the capital equipment itself and the corporate love affair with staying on the leading edge of manufacturing know-how. "We tend to get wrapped up in our own technology," says Moyer, who stresses that attainment of maximum manufacturing efficiency can be an outright error, depending on whether the corporate strategy is to achieve cost leadership, product differentiation or market focus.

"Only when you seek cost leadership does it make sense to try to keep on the leading edge of manufacturing cost control," Moyer advises. According to this view, a product differentiation company like Cray or Compaq, or a market-focus enterprise like Sun Microsystems Inc., which concentrates intensely on the engineering marketplace, does not need to invest heavily in production cost control.

As a product's sales volume expands, a shift from product differentation to a cost-leadership strategy may be called for, according to Moyer. "When the market for a product enlarges substantially, competition is attracted and cost becomes a factor.

Moyer cites Western Digital's entry into the manufacture of video graphics components. To attain market penetration for the line, the company adopted a product differentiation approach. As volume expanded, Western Digital invested heavily in manufacturing capability to drive prices down and competitors out. As a result, Western Digital now has a huge 65% share of the $400 million market for video graphics components.

Compaq's controller Daryl White: Look for the open window in the capital markets

In part, returns on investment and equity reflect the corporate asset base, which determines the size of the denominators in the ratios. All other things being equal, it would be unreasonable to expect an integrated steel company to generate returns as high as a consulting firm or advertising agency. Return on investment (ROI) measures how efficiently management uses corporate assets and how well it preserves shareholder values. It is the ratio of net earnings to the total capital employed in the business, often consisting of both debt and equity. In the absence of long-term debt, ROI equals return on equity (ROE).

Viewed as a manufacturing company, Apple Computer Inc. would inspire awe for its 26% return on investment last year and its prospects for topping 30% in 1988. But, in fact, Apple farms out so much of its manufacturing that it qualifies as an organization of product designers. It does however, invest in people, rather than plant and equipment, with the emphasis on sales representatives and customer engineers. "We have 100 such people today and would like to have 200," says Deborah Coleman, Apple's CFO. Apple has advanced from selling just boxes to selling marketing solutions to customer problems, a transformation that mandates expansion of the field force.

If Apple is people-oriented, the software industry is even more so. "Our capital requirements are far different from those of a hardware company," says Jeffrey L. Walker, senior vice president and chief financial officer of Oracle Systems Corp. "We invest in people rather than in plants. Essentially, we have no capital requirements."

Lotus Development Corp. employs 2,400, more than 70% of them professionals, and keeping the workforce satisfied is a major corporate priority, as evidenced by annual employee opinion surveys that sound out attitudes toward management. Lotus also makes a point of determining the needs and problems of its customers. Major clients, for example, are brought into corporate headquarters in Cambridge, Mass., for executive briefings. "It seems to work," according to Martin Fahey, director of investor relations. "We've sold 4 million spreadsheets and they are being used by 7 million to 8 million people."

There is a limit to how much a software firm can reinvest in itself by hiring people, says CFO Frank Gaudette of Microsoft Corp., "because people can be absorbed only so fast. However, we are in a growth mode and we are hiring." □

Top ROI performers in U.S. electronics

Rank	Company	Return on investment 1987	Return on investment 1986	Return on equity 1987	Return on equity 1986	Fiscal 1987 sales ($ millions)	Fiscal 1987 profits ($ millions)	Fiscal year ended
1	Lotus Development	30.0%	32.8%	35.7%	42.1%	$395.6	$72.0	12/87
2	Oracle Systems	29.3%	16.1%	31.9%	18.9%	282.1	42.9	5/88
3	Microsoft	29.2%	28.2%	30.1%	28.2%	345.9	71.9	6/87
4	Apple Computer	26.0%	5.7%	26.0%	5.7%	2,661.1	217.5	9/87
5	Compaq Computer	24.8%	16.7%	34.1%	23.4%	1,224.1	136.3	12/87
6	Ashton-Tate	23.0%	22.9%	24.1%	24.6%	267.3	43.1	1/88
7	Seagate Technology	21.3%	15.4%	39.5%	16.6%	958.1	139.7	6/87
8	Western Digital	20.3%	13.0%	21.2%	22.8%	462.5	42.8	6/87
9	Cray Research	20.2%	21.7%	24.1%	28.2%	687.3	147.1	12/87
10	Inmac	20.0%	19.8%	22.9%	34.8%	165.4	7.7	7/87
11	ADC Telecommunications	19.3%	18.7%	20.1%	19.8%	166.9	15.3	10/87
12	Medtronic	19.0%	17.4%	21.9%	19.1%	653.3	86.5	4/88
13	NCR	17.7%	13.0%	19.4%	14.0%	5,640.7	419.3	12/87
14	MAI Basic Four	17.6%	15.9%	29.3%	31.4%	321.0	22.8	9/87
15	Stratus Computer	17.6%	16.3%	18.9%	17.9%	184.2	19.4	12/87
16	DEC	17.3%	10.1%	18.1%	10.8%	9,389.4	1,137.4	6/87
17	Digital Communications	17.2%	17.3%	17.2%	17.3%	181.4	27.0	6/87
18	Computer Associates	16.4%	9.2%	20.4%	14.5%	709.1	101.8	3/88
19	Intelligent Systems	16.4%	0.1%	24.7%	0.1%	163.2	10.2	12/87
20	AMP	16.3%	12.4%	18.5%	14.5%	2,317.8	249.7	12/87
21	Gerber Scientific	15.6%	11.7%	17.5%	13.1%	264.0	29.6	4/88
22	Amdahl	15.4%	5.7%	18.5%	7.9%	1,505.2	142.0	12/87
23	Tandy	15.3%	11.8%	17.6%	15.1%	3,452.2	242.3	6/87
24	Measurex	15.2%	13.3%	15.8%	13.9%	227.4	26.8	11/87
25	Tandon	15.2%	-101.4%	18.3%	122.7%	289.1	17.1	12/87
26	Logicon	15.0%	10.5%	15.0%	10.5%	218.9	9.1	3/88
27	Tandem Computers	14.4%	11.7%	14.6%	11.9%	1,035.5	105.6	9/87
28	Atari	14.2%	23.3%	26.3%	23.8%	493.2	44.2	12/87
29	3Com	14.0%	12.9%	14.4%	13.2%	251.9	22.5	5/38
30	MiniScribe	14.0%	22.3%	27.8%	30.6%	362.5	28.1	12/87
31	Pitney Bowes	13.5%	14.3%	19.2%	18.2%	2,250.5	199.4	12/87
32	Molex	13.3%	12.0%	13.7%	12.6%	386.8	43.4	6/87
33	AST Research	13.1%	31.0%	13.1%	31.4%	206.0	13.0	6/87
34	Micropolis	12.7%	16.5%	19.6%	16.5%	288.3	27.2	12/87
35	Intergraph	12.2%	13.7%	12.3%	14.2%	641.1	69.9	12/87
36	Dynatech	12.1%	14.1%	16.1%	19.2%	367.8	24.5	3/88
37	Diasonics	12.1%	-18.8%	14.4%	-22.7%	267.6	15.2	12/87
38	Watkins-Johnson	12.0%	13.3%	14.7%	16.8%	264.3	17.1	12/87
39	IBM	12.0%	12.0%	13.7%	13.9%	54,217.0	5,258.0	12/87
40	E-Systems	11.8%	13.8%	14.1%	16.3%	1,227.2	60.4	12/87
41	Scientific-Atlanta	11.6%	-4.3%	12.0%	-5.1%	495.3	24.3	6/87
42	Marshall Industries	11.4%	4.7%	15.8%	8.4%	420.4	17.6	5/88
43	Aydin	11.1%	10.7%	12.6%	11.6%	149.2	8.8	12/87
44	Hewlett-Packard	10.6%	10.9%	12.8%	11.8%	8,090.0	644.0	10/87
45	Mentor Graphics	10.5%	6.2%	10.8%	7.1%	221.8	20.3	12/87
46	Diebold	10.3%	10.6%	10.5%	10.9%	439.1	35.8	12/87
47	Ultimate	10.0%	14.5%	12.6%	15.5%	209.2	13.0	4/88
48	Wyse Technology	9.9%	10.2%	17.0%	19.6%	456.6	28.0	3/88
49	Texas Instruments	9.2%	2.0%	11.4%	2.3%	5,594.5	256.9	12/87
50	Applied Magnetics	9.2%	4.0%	9.5%	4.1%	211.9	14.2	9/87

(Continued)

Top ROI performers in U.S. electronics

Rank	Company	Return on investment 1987	Return on investment 1986	Return on equity 1987	Return on equity 1986	Fiscal 1987 sales ($ millions)	Fiscal 1987 profits ($ millions)	Fiscal year ended
51	General Instrument	9.1%	2.8%	12.0%	4.0%	$1,155.5	$66.2	2/88
52	Dynascan	9.1%	8.2%	14.5%	16.2%	191.6	6.6	12/87
53	Sun Microsystems	9.0%	9.4%	15.1%	11.0%	537.5	36.3	6/87
54	Unisys	8.7%	-0.7%	12.7%	-1.1%	9,712.9	578.0	12/87
55	Intel	8.5%	-10.9%	13.4%	-14.4%	1,907.1	175.5	12/87
56	Motorola	8.3%	5.7%	10.2%	7.0%	6,707.0	308.0	12/87
57	Computer Consoles	8.1%	-2.6%	29.9%	-23.1%	148.4	9.6	12/87
58	Avantek	7.5%	10.9%	7.5%	10.9%	213.7	11.6	12/87
59	Xerox	7.5%	6.8%	10.4%	9.5%	10,320.0	578.0	12/87
60	Genicom	7.5%	12.9%	21.5%	18.9%	302.2	12.6	12/87
61	Harris	7.4%	5.4%	8.6%	6.6%	2,079.0	84.5	6/87
62	Altos Computer Systems	7.4%	18.7%	9.1%	19.8%	153.9	9.7	6/87
63	Lor[illegible]	7.0%	5.1%	17.0%	15.8%	1,440.8	74.3	3/88
64	Honeywell	7.0%	0.4%	11.3%	0.6%	6,679.3	253.7	12/87
65	Anthem Electronics	6.7%	7.5%	7.3%	7.5%	196.9	5.0	12/87
66	GM Hughes Electronics	6.7%	6.1%	7.4%	6.7%	10,481.0	521.1	12/87
67	Cherry Electrical	6.6%	2.8%	10.4%	4.4%	194.6	7.4	2/88
68	Apollo Computer	6.3%	3.0%	9.6%	4.9%	553.7	21.7	12/87
69	CTS	6.3%	-16.0%	8.3%	-22.8%	261.1	10.5	12/87
70	Veeco Instruments	6.2%	0.3%	9.2%	0.4%	195.6	9.2	9/87
71	Prime Computer	6.1%	10.3%	12.9%	10.7%	960.9	64.8	12/87
72	Maxtor	6.0%	9.8%	11.9%	20.4%	271.2	14.1	3/88
73	National Semiconductor	5.9%	-2.5%	6.2%	-2.8%	2,469.7	62.7	5/88
74	Pioneer-Standard Electronics	5.8%	2.2%	15.4%	6.3%	254.6	5.2	3/88
75	Analog Devices	5.6%	7.6%	6.1%	8.7%	370.4	18.7	10/87
76	Recognition Equipment	5.6%	6.0%	8.4%	9.1%	264.7	11.2	10/87
77	ISC Systems	5.4%	12.0%	6.5%	14.7%	168.5	6.5	6/87
78	Litton Industries	5.3%	2.8%	13.1%	7.0%	4,419.7	138.1	7/87
79	Micom Systems	5.3%	1.4%	5.6%	1.5%	223.4	9.8	3/88
80	DSC Communications	5.1%	3.3%	6.9%	5.5%	312.4	14.6	12/87
81	SCI Systems	5.0%	7.0%	12.0%	12.0%	552.9	16.0	6/87
82	Augat	4.8%	-3.6%	5.4%	-4.4%	313.2	11.5	12/87
83	AVX	4.8%	-1.5%	8.5%	-2.0%	271.9	15.8	12/87
84	Oak Industries	4.8%	-30.6%	7.2%	-50.7%	182.2	5.7	12/87
85	Wyle Laboratories	4.3%	4.8%	6.5%	5.3%	368.0	5.8	1/88
86	Cubic	4.1%	0.7%	7.1%	1.0%	361.8	7.9	9/87
87	Varian Associates	4.1%	-3.0%	4.9%	-3.6%	982.8	21.4	9/87
88	BRIntec	4.0%	8.6%	10.0%	21.5%	293.7	5.9	12/87
89	VLSI Technology	3.4%	0.0%	5.7%	0.0%	172.0	8.1	12/87
90	Mark IV Industries	3.1%	3.9%	18.4%	25.3%	403.0	17.0	2/88
91	Wang Laboratories	3.1%	2.3%	4.8%	3.5%	2,836.7	70.7	6/87
92	Cipher Data Products	3.1%	5.4%	3.1%	5.4%	178.2	4.3	6/87
93	Gould	3.0%	3.6%	5.2%	6.2%	933.4	25.0	12/87
94	Avnet	2.6%	3.1%	3.5%	3.7%	1,547.1	22.8	6/87
95	Sun Electric	2.5%	3.4%	4.1%	27.5%	203.9	3.3	10/87
96	Andrew	2.2%	5.7%	2.5%	6.6%	223.2	3.8	9/87
97	LSI Logic	2.2%	1.1%	3.5%	1.5%	262.1	10.7	12/87
98	John Fluke	1.7%	8.5%	1.9%	9.8%	206.3	2.0	9/87
99	Control Data	1.7%	-20.0%	2.4%	-31.0%	3,366.5	25.0	12/87
100	Singer	1.5%	6.2%	3.7%	9.6%	1,902.7	23.4	12/87

Source: ELECTRONIC BUSINESS

Why defense firms fret over the Pentagon's computer R&D

DOD budget cuts and DARPA's new passion for pure research may mean that the Strategic Computing Program lacks the commercial punch it once promised

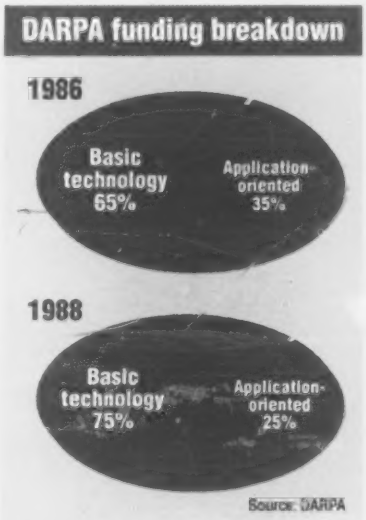
BY DWIGHT B. DAVIS

Five years ago last month, the Pentagon's Defense Advanced Research Projects Agency (DARPA) embarked on a 10-year program intended to revolutionize computer technologies ranging from microelectronics to artificial intelligence to system architectures. The initiative was dubbed the Strategic Computing Program, or SCP, and enthusiastic backers predicted it would generate technologies with vast commercial as well as military potential. In fact, given its subject scope and anticipated funding of $600 million over its first five years, many believed the SCP would serve as America's answer to Japan's then-new Fifth-Generation Computer Project.

Now at its midpoint, the SCP has already spawned a number of commercial products and advanced many computer and electronics technologies. But many of its early goals — criticized by some as unrealistic from the start — have been scaled back or eliminated. Meanwhile, beset by congressional cutbacks, the program disbursed just $326 million in contract funds to university and industry researchers through fiscal year 1987. So now, defense-electronics firms are worrying that the program may not produce for them the great gains it once promised.

However, those who pin high hopes on the DARPA computing program do so with some historical justification. Since it was established in 1958 and charged with the fostering and management of advanced research projects assigned by the Secretary of Defense, DARPA has been arguably the nation's most successful research agency. An early focus on space science and technology soon broadened to encompass strategic and tactical weapons development, nuclear test verification techniques, basic sciences research, and information-processing technology.

In the last two categories, DARPA funding and supervision was instrumental in the development of gallium arsenide (GaAs) microcircuitry, VLSI chips, computer time-sharing and interactive computer graphics. The agency-funded Arpanet became the world's first widespread packet-switched network, and served a key role in the collaborative development of other computer and communications technologies by linking dispersed researchers around the country. DARPA was the first significant backer of the fledgling field of artificial intelligence in the late 1950s, and its involvement in computer architectures runs the gamut from the Illiac IV, the first parallel-processing supercomputer, to today's frontier research in neural network designs.



DARPA clearly favors the "R" in R&D

Warm reception

Little wonder then, that many in 1983 greeted the SCP with less-than-guarded optimism. In the electronics and defense industries, the reception was especially warm. Not only would SCP contractors win sizable grants to perform the necessary R&D, but virtually all of the targeted technologies lent themselves to "dual use"; that is, they held potential for commercial as well as military application. And, since virtually all of the SCP activities are nonclassified, companies performing work under the program are under no constraints when it comes to applying the DARPA research to marketplace products.

In some cases, SCP funds have been directed even at existing commercial development projects in an attempt to stimulate the production of products that DARPA deems relevant to its objectives. Such was the case with the agency's backing of Thinking Machines Corp. in its development of the Connection Machine, a parallel processor with as many as 64,000 processing units. "DARPA essentially bought the first machine in advance," explains John Mucci, vice president for sales and marketing at Cambridge, Massachusetts-based Thinking Machines.

Since Thinking Machines delivered the first CM/1 model to DARPA in November 1985, the company has shipped 12 to 15 million-dollar-plus CM/1s to other buyers and has sold several dozen of its second-generation CM/2 parallel processors, Mucci says. And while the company obviously benefited from using DARPA funding to help bankroll its product development, DARPA as well as Thinking Machines benefits if the product does well in the marketplace

Earl Keleny

because success attracts software and support more easily than would a special-purpose machine, Mucci argues.

For its part, DARPA has always walked a tightrope between sticking to the military ramifications of its programs on one side and proclaiming the benefits of the commercial spin-offs on the other. With the SCP, both aspects were stressed from the start.

On the military side, the SCP broke from traditional DARPA strategy, which usually established a clear gap between the basic research that the agency funded and the eventual application of the research in military systems. With the SCP, DARPA initially set up as goals three prototype military systems — the driverless "autonomous land vehicle"; a "pilot's associate," which would assist the decision-making of military airmen; and a naval battle management system — that would serve as demonstration testbeds for the basic technologies being developed. By establishing such well-defined application goals, the agency hoped to direct better the basic research and to help "pull" it toward timely completion.

The agency later added three more target applications in smart weapons, air/land battle management, and radar imagery analysis. SCP funding was split, with approximately 65% of the budget going to "technology base" contracts in AI, multiprocessor architectures, microelectronics, and software; and 35% devoted to integrating these technologies into the military system prototypes.

Big promises

Despite this unusual — for DARPA — establishment of clear military applications as part of the SCP, the agency recognized the value of commercial spin-offs both to corporate contractors and to congressional funding sources. The 1983 SCP prospectus stated: "The Strategic Computing Program promises the production of machine intelligence technology that will enable yet another major cycle of new economic activity in the computer and electronics industry. . . . Spin-offs from a successful Strategic Computing Program will surge into our industrial community."

The breadth of the SCP funding across the electronics industry gives some credence to these early claims. To achieve high speeds, tight packaging, and radiation resistance in microcircuitry, DARPA let contracts to Honeywell Inc. to develop hybrid optical and switched bus interconnects; to McDonnell Douglas Corp. for a GaAs pilot line; to Rockwell International Corp. for optoelectronic interconnects, optical crossbar switches, and GaAs multifunction arrays; to Westinghouse Electric Corp. for a GaAs-on-sapphire program; to Sparta Inc. for a photorefractive memory system; and to Cyberoptics for multiple frequency striping.

In machine architectures, DARPA has funded a number of multiprocessor design projects, in part to hedge its bets among several competing configurations. These have included Thinking Machine's Connection Machine; Bolt Beranek and Newman Inc.'s Butterfly; General Electric Co.'s WARP processor; IBM's RP-3 architecture; and the DADO/DSP processor from AT&T's Technologies operation. The SCP also bankrolled Texas Instruments Inc.'s develop-

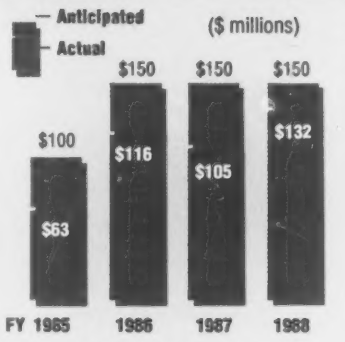
ment of its Compact LISP machine.

Running on top of this hardware will be an array of AI technologies. Computer vision systems are required by the autonomous land vehicle and smart weapons programs and will have broader application in photo interpretation and robotic manipulation roles. Work in this discipline includes obstacle avoidance and path planning at the Hughes Research Laboratory of GM Hughes Electronics; spatial representation and modeling at SRI International; and vision modeling at GE.

Meanwhile, speech processing and natural language understanding have direct application to both the battle management programs and to the pilot's associate system. Here, Bolt Beranek is researching advanced continuous speech and language understanding; TI is developing a speech database; SRI is investigating the processing of written discourse as well as speaker independence; and Dragon Systems is working on the problem of interpreting speech in real time.

Finally, in the area of knowledge-based systems, two of the leading commercial AI vendors, Teknowledge Inc. and IntelliCorp Inc., have been working under SCP contracts to develop the programming environments and tools necessary to create the expert systems that will reside at the heart of each prototype application.

Strategic computing program funds



Does not include $50 million in annual funds for DARPA's non-SCP computer research

Source: DARPA

DARPA hasn't gotten as much computer-research money as it hoped for

While it's inevitable that these SCP projects and others like them will continue to alter the complexion of the information-processing marketplace, it's no longer clear that the impact will be as strong and as pervasive as once expected. Part of the reason for this uncertainty is the natural consequence of budget cutting. When funding drops from an anticipated $150 million for the year to an actual $105 million, as happened in fiscal 1987, a consequent reduction in program influence is unavoidable.

It's the combination of these cuts with a shift in DARPA's emphasis that has some contractors especially worried. The first phase of project funding established set timetables to demonstrate technological advances within the context of the application prototypes. But DARPA's current management team has deemphasized the integration of the technologies in the prototypes, according to some contractors, preferring to focus more on the independent development of the basic technologies themselves.

The consequences of this shift, including its impact on the speed with which the research can be commercialized, are debated even among contractors working under the same prototype projects. In the autonomous land vehicle (ALV) program, for example, researchers are split in their opinions of the importance of the changes.

Martin Marietta Corp. has served from the start as the company charged with integrating the various ALV technologies into a functioning vehicle prototype. The company is working under a $22 million SCP contract due to expire in 1990, although ALV program manager Robert Douglass admits future budget cuts may reduce the amount actually spent. Through 1987, the prototype ALV had met functional milestones that included an on-road

DARPA: Commitment remains strong

Despite some researchers' opinions to the contrary, the person responsible for administering the Strategic Computing Program maintains there has been no slippage in either the program's ultimate objectives or in DARPA's commitment to supporting fundamental SCP technologies. Budget cuts "have forced us to be more frugal," says Jack Schwartz, director of DARPA's Information Science and Technology Office, "but we're still following the program's goals pretty well."

In any case, Schwartz says, progress in some SCP disciplines is more "idea constrained" than funding limited. "Doubling the money in certain areas of basic research won't help, because progress is dependent upon someone having a 'Eureka!' type of insight," he says. Schwartz places certain fields of artificial intelligence, including natural language processing, among those disciplines still waiting on conceptual breakthroughs.

Some development programs such as those in VLSI and parallel processing clearly have benefited from the infusion of SCP funds, according to Schwartz. In parallel processing, advances have occurred more rapidly than even the SCP's ambitious goals anticipated. "Strategic Computing funding definitely pulled this country ahead of the foreign competition in this field, which is nice for a change," he says.

Schwartz disagrees with critics who say DARPA has universally backed off from the SCP's application goals and is no longer funding the transition of research into integrated systems. Although funding of applications research has fallen from approximately one-third to about one-quarter or one-fifth of the overall SCP budget, the effect of this shift has been felt more strongly in some programs than in others. The autonomous land vehicle project, after successfully meeting its first phase application goals, has seen cutbacks in its second phase. But he cites the pilot's associate program as one that remains quite active in its pursuit of long-standing application goals. □

4.5- to 5-kilometer run averaging 14 km/hr and a top speed of 20 to 22 km/hr.

The project's second phase, initiated in March of this year, shifted the emphasis to off-road navigation, where speeds of 3 km/hr have been achieved. But, "phase II is not so concerned with achieving fixed performance milestones," Douglass says.

Douglass attributes the change to a different philosophy among the DARPA managers now directing the SCP. In part, he says, "There was a feeling that the naming of specific performance goals was not appropriate to a research and development program, since it sometimes amounted to the scheduling of research breakthroughs."

In addition, the ALV's ambitious 10-year goals were viewed by many outside observers as unattainable. The ALV, according to the SCP prospectus, "must plan routes using digital terrain and environmental data, devise strategies for avoiding unanticipated obstacles, estimate the vehicle's position from landmark and other data, update the on-board digital terrain database, generate moment-to-moment steering and speed commands, and monitor vehicle performance and on-board systems," all while traveling off-road at speeds of up to 60 km/hr.

Hughes Research Laboratory has several SCP contracts, including two under the ALV program being pursued by the lab's Artificial Intelligence Center. One, the development of an off-road, real-time planning and navigation system, was a $1.6 million contract due to expire this fall. The second is a $1.9 million contract that runs through next March and encompasses the use of computer vision to identify and avoid obstacles and assist in path planning. "We are being directly affected by the changes in the SCP program," says David Y. Tseng, manager of the AI Center, "and we don't anticipate any follow-ons to current contracts."

Too goal-oriented?

While Tseng agrees that the SCP "was too goal- and breakthrough-oriented," he thinks the deemphasis on goals has hurt the program. "When doing research, one needs to find out early on if the research is working and how the fundamental components will fit into an integrated system. The strength of application goals was that they allowed us to measure how our basic research applied to realistic situations."

The loss of this goal-driven orientation will have ramifications into how quickly the ALV research will appear in nonmilitary systems, Tseng believes. For example, Hughes sees potential applications of the vision and navigation technologies in autonomous factory vehicles as well as in underseas research probes.

But "there is a huge gap between the publishing of research papers and the building of system prototypes," Tseng says. And because the SCP is no longer providing the bridge between these two stages, "the speed with which spin-offs occur and with which the technologies move into users' hands will really be affected," he warns.

A sampling of electronics firms with large Strategic Computing contracts

Company	($ millions) Total SCP awards to date
Bolt Beranek and Newman	$31.7
Martin Marietta	21.1
Texas Instruments	21.1
Rockwell International	15.1
Thinking Machines	12.8
Hughes Research Labs	11.4
General Electric	6.2
Teknowledge	5.8
Lockheed Electric	4.0
Honeywell	3.8
AT&T Technologies	3.3

Source: DARPA

"Without DARPA funds, AI wouldn't be where it is today"
— Frank Kuo of SRI International

Others are less pessimistic about the effect of the SCP program changes. "The program is every bit as strong as it always was," says Frank Kuo, associate director and senior science advisor at SRI International's Computer and Information Sciences division. Any problems that may exist "are not due to a lack of direction at DARPA, but to a lack of available funds," according to Kuo.

SRI is working under several AI-related contracts in computer vision, speech processing and natural language processing. The nonprofit contract research house holds the patent rights to any of its developments and, although SRI focuses more on fundamental research than on technology commercialization, Kuo notes that the company is free to license any of its patents to outside firms. "Without DARPA funding, AI wouldn't be anywhere near where it is today," Kuo says.

Doubts

Others hope such optimism bears out. One is David J. Mishelevich, vice president and general manager of IntelliCorp's Applications and Research division. But he has his doubts: "There are significant AI cutbacks in the DARPA budget, which is reason for concern," he says. IntelliCorp is now in the second phase of a four-year, $2.8 million contract to develop expert system development tools. Advances made under the contract's first phase were quickly incorporated in the company's Knowledge Engineering Environment system, of which approximately 2,100 copies have shipped.

Now DARPA is emphasizing software engineering more than basic AI research, according to Mishelevich, and he worries about the consequences. Although IntelliCorp and its competitors will continue their own in-house research on product development, SCP funds or not, the commercial AI shops won't pursue as broad an agenda as they might with continued DARPA support. "There are a lot of research areas out of the commercial mainstream that we can't afford to follow on our own," Mishelevich says, "and the diminishing role of DARPA in the field will hurt AI's prospects."

Whatever is concluded about DARPA's role, SCP backers can already point to a number of influential commercial successes. As Thinking Machine's Mucci says, "People will look back in several years and will credit DARPA with sharing the pride of authorship for a fundamental change in the way in which computing is done." □

Issues for the '90s: Reliability and support

The push to submicron geometries may be putting a financial strain on equipment suppliers, making it harder for start-ups to compete

BY MARK MEHLER

It's that time again — time to begin the arduous shift to the next generation of higher-speed, higher-density circuits. The goal: high yields on 4-megabit memories, microprocessors, ASICs, and other parts with feature sizes of 0.8 to 1 micron, or roughly one-tenth the width of a human hair. The current generation of advanced circuits is fabricated with 1.25- to 1.5-micron lines.

Past technology shifts have been painful, and ramping up 0.8-micron volume production promises to be difficult, as well. Although manufacturers of wafer fabrication equipment and their customers have made incredible strides in developing workable submicron processes, several key problems have yet to be adequately addressed. Equipment reliability, particulate contamination, software integration and vendor staying power are among the sticking points. And this is true for almost every type of machine used in the wafer fabrication process — in exposing and etching wafers, implanting dopants, depositing metal and performing other complex production functions.

"The current generation of equipment is very capable of doing submicron work," argues Daniel Hutcheson, vice president of VLSI Research Inc., which estimates that $3 billion of the $4 billion in worldwide wafer fabrication equipment shipped in 1988 was ultimately purchased for submicron requirements.

"Optical steppers, for example, can take you down to 0.3 micron with excimer lasers. You can etch submicron lines with low-pressure plasma etchers and the new chemical vapor deposition (CVD) systems can deposit metal in those narrow, deep steps," notes Hutcheson. "But too few U.S. equipment suppliers are focusing on reliability, whether the machines work well over time, and how well they're supported and serviced. And not enough vendors are focusing on eliminating defects, of which 80% are caused by equipment. At 0.8 micron, defects are killers."

If you add the costs of designing and building in reliability and eliminating particulates to the already awesome costs of building a machine that can do the process, the total development cost on a new-generation system can run anywhere from five to 15 times the selling price. And these are $500,000 to $2 million systems. The demands of the submicron world are going to drive undercapitalized suppliers out of the market.

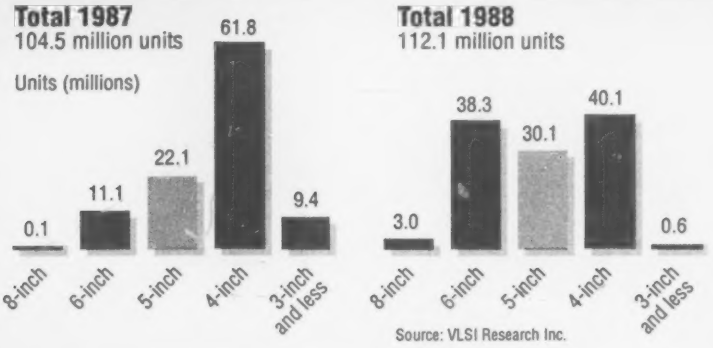
Fragmentation

Vendors and users confirm that semiconductor companies this year are more reluctant than ever to deal with venture-funded start-ups. Not only are IC makers concerned about lack of development capital, but they are afraid that venture capitalists might pull the plug in the absence of a vital new issues equity market. IBM, according to several sources, has taken a particularly hard line, backing out of dealings with little equipment companies.

"I fear that the fragmentation of . . . the domestic equipment industry is too great and our own entrepreneurs may not be able to afford development," lamented AT&T Microelectronics president William Warwick, in his keynote speech at last September's Semicon East show in Boston.

Peter Hanley, vice president of Applied Materials Inc.'s Etch Products division, agrees. "No way can a customer rely on a $10 million supplier anymore. They'll tell you, "We don't want to be 25% of your business." Reliability is a function of religiously gathering data and doing failure analysis. How can you do that effectively without a big enough installed

Worldwide wafer consumption



Source: VLSI Research Inc.

The push toward 8-inch wafers may be slower than once predicted, but it will add to the call for more reliable IC production gear

base at one customer to avoid customer-to-customer site variations? You've got to have size and [financial] strength to be a player at the 4- and 16-megabit levels."

AT&T's Warwick sees heavy consolidation, through mergers, strategic alliances and partnerships, as essential to the survival of the semiconductor equipment industry. Such action may already be underway.

William Reed, executive director of Semiconductor Equipment & Materials International, the industry's trade group, says membership, after growing from 800 in 1984 to 1,150 companies in 1987, has leveled off to about 1,200 companies in the past 12 months, reflecting some acquisitions, start-up fatalities, and a generally more realistic appraisal of entrepreneurial prospects.

For those still-breathing start-ups which have based their business plans on selling advanced equipment for submicron wafer fabrication, 1988 is a watershed. SiScan Systems Inc., a Campbell, Calif., company, has been hanging by its fingernails waiting for users to begin purchasing its laser-based linewidth measurement system. The company has sold about 30 systems in 2 years, but its market window was pushed back by performance gains in conventional optical microscopes. Senior vice president for marketing Barry Gottlieb says the company still believes that it has the only linewidth measurement tool that will do the job at 0.5 to 0.8 micron, but now is the time to convince major customers.

"We're at the crossroads," he insists. "Customers over the past few months have started to staff new fabs that will eventually [produce] 0.8-micron devices. We can offer enabling technology, but we have to beat down the industry's resistance to change, its fear of moving into new ground [with a start-up]."

Among the larger equipment vendors, progress is being made on a number of fronts. Closer working relationships with the advanced development teams of their customers are making for better targeted products. Applied's Hanley says gone forever are the days when an equipment supplier could afford the standard four-

Relax. Next year may not be "déjà vu all over again"

Fueled by a booming computer market and semiconductor makers' demand for advanced submicron technology, the IC equipment industry rebounded strongly in 1988, after a three-year slide.

VLSI Research Inc., a San Jose market analysis firm, projects total worldwide equipment sales — wafer fabrication, test, and assembly gear — will be $7.5 billion this year, up 39% over 1987. VLSI's Daniel Hutcheson adds, however, that this preliminary 1988 forecast is being upgraded, and could wind up as high as $8.6 billion, or 60% above last year. Equipment makers report backlogs of six months or more and deliveries stretching out to the third quarter of 1989.

Skeptics may note certain similarities to the "feeding frenzy" of 1984, when equipment makers reveled in new business, only to find many of those orders canceled and many of the delivered machines sitting uncrated in customer warehouses for two years. Some are inclined to cite the immortal words of Baseball Hall of Famer Yogi Berra: "It seems like déjà vu all over again."

Not so fast with those analogies, say other market observers. The semiconductor and IC equipment industries have changed greatly in the past four years. For example, notes Hutcheson, systems houses' chip inventories, which reached 22 weeks back in 1984, peaked at only nine weeks in this year's second quarter, suggesting that end users have a better handle on their needs and are successfully implementing just-in-time type programs. Semiconductor manufacturers, for their part, are less inclined to stack devices against speculative forecasts.

Meanwhile, equipment makers are not simply cranking out everything they can lay their hands on,

Both the semiconductor and IC equipment industries have changed greatly within the past four years

as they did in 1984. Martin Hammond, marketing vice president of Gemini Research, a manufacturer of epitaxial process equipment which was recently acquired by another equipment supplier, Lam Research Corp., says he is keeping a very close eye on the long-term (shipment) trend line. If Gemini's order rates get too far above that line, says Hammond, the business plan is reevaluated and those orders are revalidated. Some orders don't even get booked at all.

"We remember four years ago," he says. "We monitor our parts inventory levels more closely and we're watching like hell for obsolescence. On orders, we get one-third [of the money] down. Our business is big-ticket items, $500,000 to $1.5 million apiece. The total market is only 50 to 80 units a year. In other words, in this kind of business, you'd better be realistic about your forecast and keep the right [parts] mix on your shelf."

Other reasons why déjà vu is not repeating itself include merchant semiconductor makers' concern over future interest rates and their success in driving to 100% utilization of their old capacity. Equipment suppliers such as George Rutland, president of Ultratech Stepper, which manufactures wafer exposure machines, say the big volume buys by the likes of National Semiconductor Corp. and Intel Corp. will wait until those customers have fully assessed demand for their product portfolios.

"We haven't seen the merchants make major shifts in capacity yet," he says. "Mainly, they're buying new advanced technology and our [low-end] replacement business is a little stronger . . . but our customers are pressing the limits [of current capacity] now. Look for the big players to begin a real ramp-up fairly soon." □

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THE ASIAN WALL STREET JOURNAL, MONDAY, APRIL 25, 1988

U.S., China Magazine

Special to THE ASIAN WALL STREET JOURNAL

NEWTON, Massachusetts – Cahners Publishing Co. said it will jointly publish a quarterly high-tech business magazine in China, beginning in March 1989, with the Technology Information Research Institute, a division of the Chinese Ministry of Electronics Industry.

Cahners, the publishing unit of Reed International PLC of London, said the magazine, "Electronic Business, Chinese Edition," will be the first Chinese-language business magazine aimed exclusively at managers of computer and electronics companies in China.

Articles will be excerpted from Electronic Business, a twice-monthly trade magazine Cahners publishes in the U.S. The magazine will not be sold on newsstands, but will be sent free to Chinese managers who are deemed qualified to receive it by the ministry.

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or five-year development cycle.

"You've got be able to roll out a new machine in 18 months, to match the design cycles of [the customer]," he says. "You do that by designing in costs and reliability, and working in partnership with customers at the earliest stage to develop new processes."

Service issues

Vendors are also giving needed attention to reliability, service and support. Jerry Adomshick, customer support and technical services manager for Varian Semiconductor Equipment Group's Extrion division, a maker of ion implanters, says reliability and quality were two major factors in the "beating we took during the last recession . . . not necessarily that we had big problems, but users perceived us that way."

Varian, says Adomshick, responded in the past 12 months with new modular designs for easier preventive maintenance; and the formation of a customer support group designed "not just to go in when the machine's broken, but to make sure it is continually running."

Service contracts between user and vendor are becoming increasingly common in the IC industry, and some device makers, including AT&T, now run cooperative programs which penalize suppliers for poor uptime performance and offer financial incentives for meeting equipment utilization guarantees.

Yet another key issue at 0.8 micron is implementation of the Semi Equipment Communications Standard (SECS) for automating the IC factory. Users are pushing equipment vendors to help design and integrate new software that will finally allow machines to communicate on the shop floor, for collection and analysis of data and real-time process control. The equipment makers are not overly excited about the project.

"It's important that we make gains in automated control and reliability and issues like that," concludes John Birchak, a senior systems engineer at Intel Corp. "We have a two- or three-year window before we hit the next process bump at the 0.5-micron level, and if we don't solve the communications problems soon and ensure accurate, repeatable results, when the next fork in the road appears, it'll be too late." □

U.S. directory of plant sites and facilities

A company's offices and factories, like its cash and production machinery, are assets to be deployed as resourcefully as possible. The decisions on how best to utilize those resources are decisions for senior management.

Those decisions frequently come down to where new facilities should be located — necessary if a vendor's major market shifts geographically; if key personnel are concentrated elsewhere; if a merger forces reexamination of where the new headquarters might be; if a company is expanding enough to need new facilities; or simply if a lease is expiring.

But the decisions can't be made without the knowledge of what different regions have to offer. To make that information easier to obtain, ELECTRONIC BUSINESS once a year publishes this comprehensive directory of plant sites in the U.S.

NORTHEAST

CONNECTICUT

Contact: Mark Feinberg
Agency: Connecticut Department of Economic Development, 210 Washington Street, Hartford, Conn. 06106
Phone: (203) 566-5546

MAINE

Agency: State Development Agency, 193 State Street, Augusta, Maine 04333
Phone: (207) 289-2656

MASSACHUSETTS

Contact: Warren Dillon
Agency: S.I.T.E. Program, Department of Commerce and Development, Leverett Saltonstall Building, Government Center, 100 Cambridge Street, Boston, Mass. 02202
Phone: (617) 727-3215
Business conditions
Total electronics workforce 120,300
Average hourly wage (production line) $9.72
Average annual salary for electrical engineers . . . . . $26,700-$40,000
Number of colleges offering advanced degrees in electrical engineering, computer science and related subjects 41

NEW HAMPSHIRE

Contact: William G. Herman
Agency: Office of Industrial Development, P.O. Box 856, Concord, N.H. 03301
Phone: (603) 271-2591
Business conditions
Total electronics workforce 25,052
Average hourly wage (production line) $10.45

Average hourly wage (clerical) $7.51
Average annual salary for electrical engineers $22,000

NEW JERSEY

Contact: George Nagle
Agency: Office of Economic Research, New Jersey Department of Commerce and Economic Development, 20 West State Street, P.O. Box CN823, Trenton, N.J. 08625
Phone: (609) 292-2423
Business conditions
Total electronics workforce 181,510
Average hourly wage (production line) $11.33
Average hourly wage (clerical) $6.50
Average annual salary for electrical engineers $46,500
Number of colleges offering advanced degrees in electrical engineering, computer science and related subjects 4

NEW YORK

Contact: Raymond G. Paolino
Agency: New York Sate Department of Economic Development, One Commerce Plaza, Albany, N.Y. 12245
Phone: (518) 474-8670
Business conditions
Total electronics workforce 147,600
Average hourly wage (production line) $10.35
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 93

PENNSYLVANIA

Contact: Jack Coma
Agency: Pennsylvania Department of Commerce, Bureau of Economic Research and Legislative Analysis, Room 469, Forum Building, Harrisburg, Pa. 17120
Phone: (717) 787-4088
Business conditions
Total electronics workforce . . . 100,000+
Average hourly wage (production line) $10.17
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 41

RHODE ISLAND

Contact: Kenneth Willette
Agency: Rhode Island Department of Economic Development, 7 Jackson Walkway, Providence, R.I. 02903
Phone: (401) 277-2601
Business conditions
Total electronics workforce (manufacturing) 20,000
Average hourly wage (production line) $8.25
Average hourly wage (clerical) $6
Average annual salary for electrical engineers $40,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 2

VERMONT

Contact: Fred Newhall
Agency: Vermont Economic Development Department, 109 State Street, Montpelier, Vt. 05465
Phone: (802) 828-3221
Business conditions
Total electronics workforce 12,100
Average hourly wage (production line) $6.22
Average hourly wage (clerical) $5.68
Average annual salary for electrical engineers $34,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 1

Photography: Renee Fraser

ATLANTIC

DELAWARE

Contact: Jane Robinson

Agency: Delaware Development Office, 99 Kings Highway, P.O. Box 1401, Dover, Del. 19903

Phone: (302) 736-4271

FLORIDA

Contact: Steve Mayberry

Agency: Florida Department of Commerce, Division of Economic Development, 501B Collins Building, 101 East Gaines Street, Tallahassee, Fla. 32399-2000

Phone: (904) 488-6300

Business conditions
Total electronics workforce 76,451
Average hourly wage (production line) $4.35
Average hourly wage (clerical) $4.87
Average annual salary for electrical engineers $24,100
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 8

GEORGIA

Contact: Pepe Cummings

Agency: Department of Industry and Trade, 230 Peachtree Street, Suite 700, Atlanta, Ga. 30303

Phone: (404) 656-3545 or (404) 656-7795

Business conditions
Total electronics workforce (manufacturing) 31,922
Average hourly wage (production line) $8.34
Average hourly wage (clerical) $6.92
Average annual salary for electrical engineers $41,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 1

MARYLAND

Contact: Jim Pifer

Agency: Office of Business and Industrial Development, Department of Economic and Community Development, 217 East Redwood Street, 10th floor, Baltimore, Md. 21202

Phone: (301) 333-6985

NORTH CAROLINA

Contact: Earle L. Bradley

Agency: North Carolina Department of Commerce, 430 N. Salisbury Street, Raleigh, N.C. 27611

Phone: (919) 733-4094

Business conditions
Total electronics workforce 60,000
Average hourly wage (production line) $9.39
Average hourly wage (clerical) $7.23
Average annual salary for electrical engineers $29,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 5

SOUTH CAROLINA

Contact: Sena H. Black

Agency: South Carolina State Development Board, Research and Information Resources, 1201 Main Street, Columbia, S.C. 29202

Phone: (803) 737-0400

Business conditions
Total electronics workforce 49,200
Average hourly wage (production line) $8.30
Average hourly wage (clerical) $6.84
Average annual salary of electrical engineers . . . . . $28,000-$45,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 2

VIRGINIA

Contact: Hugh D. Keogh

Agency: Virginia Department of Economic Development, 1000 Washington Building, Richmond, Va. 23219

Phone: (804) 786-3791

WEST VIRGINIA

Contact: Sammi Baronner

Agency: Governer's Office of Community and Industrial Development, Capitol Complex, Charleston, W.Va. 25305

Phone: (304) 348-0400

Business conditions
Total electronics workforce 2,700
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 1

SOUTH

ALABAMA

Contact: Albert McDonald

Agency: Agriculture and Industry Department, 1445 Federal Drive, Montgomery, Ala. 36109

Phone: (205) 261-2650

ARKANSAS

Contact: Mary McFarland

Agency: State Data Center/Research and Public Service, University of Arkansas, 33rd and University, Little Rock, Ark. 72204

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Jeff Stone, Office of Economic Development, Arundel Center, Annapolis, Maryland 21401
Telephone: 301/280-1122

KENTUCKY

Contact: Ronald Morgan

Agency: Kentucky Commerce Cabinet, 2400 Capital Plaza Tower, Frankfort, Ky. 40601

Phone: (502) 564-4886

Business conditions

Total electronics workforce 6,060
Average hourly wage (production line) $10.85
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 3

LOUISIANA

Contact: Dave Bowman

Agency: Louisiana Department of Commerce, Box 94185, Baton Rouge, La. 70804

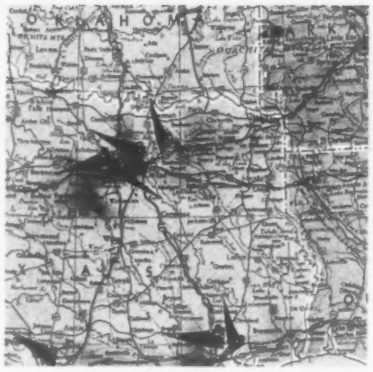
Phone: (504) 342-5405

MISSISSIPPI

Contact: J. Mac Holladay

Agency: Mississippi Department of Economic Development, 1201 Sillers Building, 500 High Street, Jackson, Miss. 32901

Phone: (601) 354-7011



OKLAHOMA

Contact: Harley Lingerfelt

Agency: Industrial Division, Department of Commerce, 6601 Broadway Extension, Oklahoma City, Okla. 73116-8214

Phone: (405) 843-9770

Business conditions

Total electronics workforce 17,500
Average hourly wage (production line) $10.30
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 3

TENNESSEE

Contact: John M. Crothers

Agency: State of Tennessee Department of Economic and Community Development, 320 6th Avenue North, Rachel Jackson Building, 6th floor, Nashville, Tenn. 37219-5308

Phone: (615) 741-5070

TEXAS

Contact: Jerri Wiegman

Agency: Texas Department of Commerce, P.O. Box 12728, Capitol Station, Austin, Texas 78711

Phone: (512) 472-5059

MIDWEST

ILLINOIS

Contact: Paul M. O'Connor

Agency: Illinois Department of Commerce and Community Affairs, 100 West Randolph, Suite 3400, Chicago, Ill. 60601

Phone: (312) 917-7179

Business conditions

Total electronics workforce 121,800
Average hourly wage (production line) $12.50
Average hourly wage (clerical) $9.46
Average annual salary for electrical engineers $33,787
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 186

INDIANA

Contact: David H. Borst

Agency: Department of Commerce, Industrial Development Division, One North Capitol Plaza, Suite 700, Indianapolis, Ind. 46204-2288

Phone: (317) 232-8888

IOWA

Contact: Bob Henningsen

Agency: National Marketing, Iowa Development of Economic Development, 200 East Grand Avenue, Des Moines, Iowa 50309

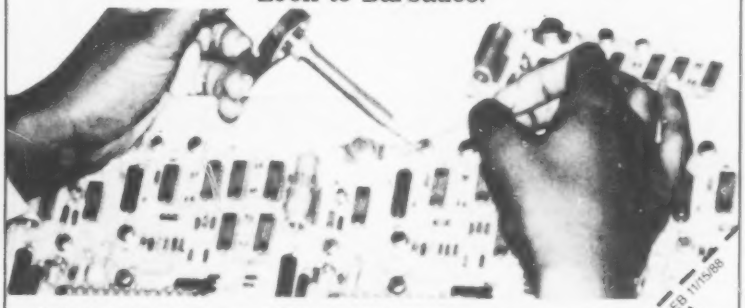
Phone: (515) 281-3210

Business conditions

Total electronics workforce 23,595
Average hourly wage (production line) $10.77
Average hourly wage (clerical) $6.28
Average annual salary for electrical engineers $32,386
Number of colleges and universities offering

continued

Looking to reduce electronics manufacturing costs? Look to Barbados.



Barbados has the advantages of a fully developed business center. International sea and air ports. The most advanced telecommunications system in the Caribbean. A skilled and productive work force. A stable political and economic environment. Lucrative tax concessions and duty free imports. As well as preferential access to EEC, Canadian and USA markets.

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(212) 867-6420

EB 11/15/88

Yes, I am eager to reduce manufacturing cost.

Name Title
Company Name
Address
City State Zip
Area of Interest

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advanced degrees in electrical engineering, computer science and related subjects . . 5

KANSAS

Contact: Ed Riemann

Agency: Kansas Department of Commerce, 400 W. 8th Street, Site 500, Capitol Towers, Topeka, Kan. 66603

Phone: (913) 296-3483

Business conditions

Total electronics workforce 9,650
Average hourly wage (production line) $6.40
Average hourly wage (clerical) $6.50
Average annual salary for electrical engineers . . . . . $25,000-$50,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 3

MICHIGAN

Contact: Greg Main

Agency: Manufacturing Services, P.O. Box 30225, Lansing, Mich. 48909

Phone: (517) 373-3550

MINNESOTA

Contact: Harry Rosefelt

Agency: Department of Energy and Economic Resources, 900 American Center Building, 150 E. Kellogg Boulevard, St. Paul, Minn. 55101

Phone: (612) 296-5010

MISSOURI

Contact: Ed Martin

Agency: Missouri Department of Economic Development, P.O. Box 118, Jefferson City, Mo. 65102

Phone: (314) 751-4539

Business conditions

Total electronics workforce 82,000
Average hourly wage (production line) $9.73
Average hourly wage (clerical) $6.30
Average annual salary for electrical engineers $30,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 52

NEBRASKA

Contact: Bob Lewis

Agency: Recruitment Division, Nebraska Department of Economic Development, P.O. Box 94666, Lincoln, Neb. 68509

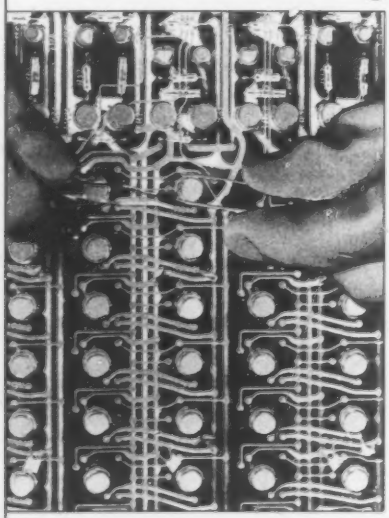
Phone: (402) 471-3111

Business conditions

Total electronics workforce 8,258
Average hourly wage (production line) $9.28
Average hourly wage (clerical) $4.67

continued

In Scarborough, Ontario, you've got it made



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Mr. Frank Miele B.E.S., Ec.D.
Executive Director
Economic Development Department
City of Scarborough
150 Borough Drive
Scarborough, Ontario
Canada M1P 4N7
Tel. (416) 396-7743

CITY OF SCARBOROUGH · ONTARIO

Average annual salary for electrical engineers $50,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . 2

NORTH DAKOTA

Contact: Shirley R. Kykshoorn
Agency: Office of Intergovernment Assistance, State Capitol, 14th floor, Bismarck, N.D. 58505
Phone: (701) 224-2467

OHIO

Contact: Keith Ewald
Agency: Ohio Data User Center/Development Office, 30 E. Broad Street, 26th floor, P.O. Box 1001, Columbus, Ohio 43266-0101
Phone: (614) 466-2480

SOUTH DAKOTA

Agency: Department of State Development, Capitol Lake Plaza, Pierre, S.D. 57501
Phone: (605) 773-5032

WISCONSIN

Contact: Rolf Wegenke
Agency: State of Wisconsin Department of Development, Division of Economic and Community Development, State Justice Building, P.O. Box 7970, 123 W. Washington Avenue, Madison, Wis. 53707
Phone: (608) 266-3203

MOUNTAIN

ARIZONA

Contact: Janice M. Schaefer
Agency: Arizona Department of Commerce, 1700 West Washington, Phoenix, Ariz. 85007
Phone: (602) 255-5374

COLORADO

Contact: Fred Neihaus
Agency: Colorado Office of Business Development, 1625 Broadway, Suite 1710, Denver, Colo. 80202
Phone: (303) 892-3840

IDAHO

Contact: Jay Engstrom
Agency: Department of Commerce, 700 West State Street, Boise, Idaho, 83720
Phone: (208) 334-4719

MONTANA

Contact: Rick Jones
Agency: Department of Commerce, 1424 Ninth Avenue, Helena, Mont. 59620
Phone: (406) 444-3923

NEVADA

Contact: Jean Towne
Agency: Commission of Economic Development, Capitol Complex, 600 E. Williams, Suite 203, Carson City, Nev. 98701
Phone: (702) 885-4325

NEW MEXICO

Contact: Gilbert K. St. Clair
Agency: Albuquerque Economic Development Inc., P.O. Box 25100, Albuquerque, N.M. 87125

continued

Quincy . . .

Where Innovation and Technology Meet . . .

and Stay!

Quincy, Illinois is a breeding ground for electronics firms. Quincy has been able to nurture and sustain its pioneer firm, Harris Corporation (formerly Gates Radio), for the past 66 years. The benefits offered by this community have drawn numerous electronics executives to establish such new and innovative companies as Quintron Corporation, Plexsys Corp, MicroENERGY, Inc., and Vision Systems, Inc. in Quincy.

WESTERN ILLINOIS

"Quintron continues to successfully tap Quincy's abundant resources of an existing high-tech labor pool skilled in the manufacturing of electronic assemblies. Our employees are the principal reason Quintron has experienced such steady growth over the past 18 years."

John J. Nevin
President
Quintron Corporation

To support and assist its labor force, a **MS/EE degree** and training are offered through unique in-house satellite programs (CONVOCOM) and the local community college. Quincy's central U.S. location provides easy access to domestic and international markets.

GREDF

"The electronics firms here have attracted support industries. We welcome additional industry growth and invite inquiries."

James E. Mentesti
Executive Director
Great River Economic Development Foundation (GREDF)

A supporter of this growth in Quincy is Central Illinois Public Service. Providing their customers with:

- Reliable energy service
- Abundant electric reserve capacity
- Competitive incentive rates

CIPS

For further information about Quincy/Adams County, Illinois, contact:

James E. Mentesti
Executive Director
GREDF
314 Main St.
Quincy, IL 92301
(217) 223-4313

Ken Caldwell
Economic Development Representative
CIPS
104 E. Third St.
Beardstown, IL 62618
(217) 323-2173

In cooperation with the . . . ois Department of Commerce and Community Affairs Corridor of Opportunity program.

Phone: (505) 764-3750
Business conditions
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . . . 4

UTAH

Contact: David Grant
Agency: Department of Community and Economic Development, 6150 State Office Building, Salt Lake City, Utah 84114
Phone: (801) 538-3036

WYOMING

Contact: John Logan
Agency: Economic Development and Stabilization Board, The Herschler Building, 3rd floor, East Wing, Cheyenne, Wyo. 82002
Phone: (307) 777-7284

PACIFIC

ALASKA

Contact: Paul Fletcher
Agency: Department of Commerce Office of Enterprise, State Office Building, Pouch D, Juneau, Alaska 99811
Phone: (907) 465-2018

CALIFORNIA

Contact: Don Backstrom
Agency: Industrial Development Financial Advisory Commission, 915 Capitol Mall, Room 280, Sacramento, Calif. 95814
Phone: (916) 445-9597

HAWAII

Contact: Norman Reyes
Agency: Planning and Economic Development Department, 250 South King Street, 7th floor, Honolulu, Hawaii 98604
Phone: (808) 548-4620

OREGON

Contact: Steve Petersen
Agency: Oregon Economic Development Department, 595 Cottage Street NE, Salem, Ore. 97310
Phone: (503) 373-1200
Business conditions
Total electronics workforce 44,300
Average hourly wage (production line) $4.34
Average hourly wage (clerical) $4.37
Average annual salary for electrical engineers (entry level) $27,000
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 15

WASHINGTON

Contact: Daniel D. Cudaback
Agency: Domestic and International Investment Division, 312 First Avenue North, Seattle, Wash. 98109
Phone: (206) 464-6282
Business conditions
Total electronics workforce 148,698
Average hourly wage (production line) . . . . . $4.50-$8
Average hourly wage (clerical) . . $4.05-$8
Average annual salary for electrical engineers $32,500
Number of colleges and universities offering advanced degrees in electrical engineering, computer science and related subjects . 12

Open your eyes and see just how many subjects are covered in the new edition of the Consumer Information Catalog. It's free just for the asking and so are nearly half of the 200 federal publications described inside. Booklets on subjects like financial and career planning; eating right, exercising, and staying healthy; housing and child care; federal benefit programs. Just about everything you would need to know. Write today. We'll send you the latest edition of the Consumer Information Catalog, which is updated and published quarterly. It'll be a great help, you'll see. Just write:

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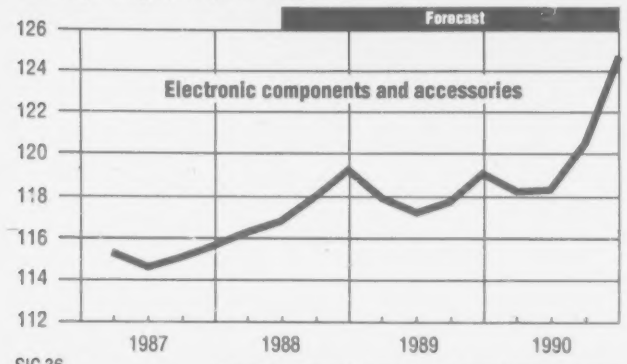
Producer price index — Electronic components

Quarterly averages, 1st quarter 1982 = 100

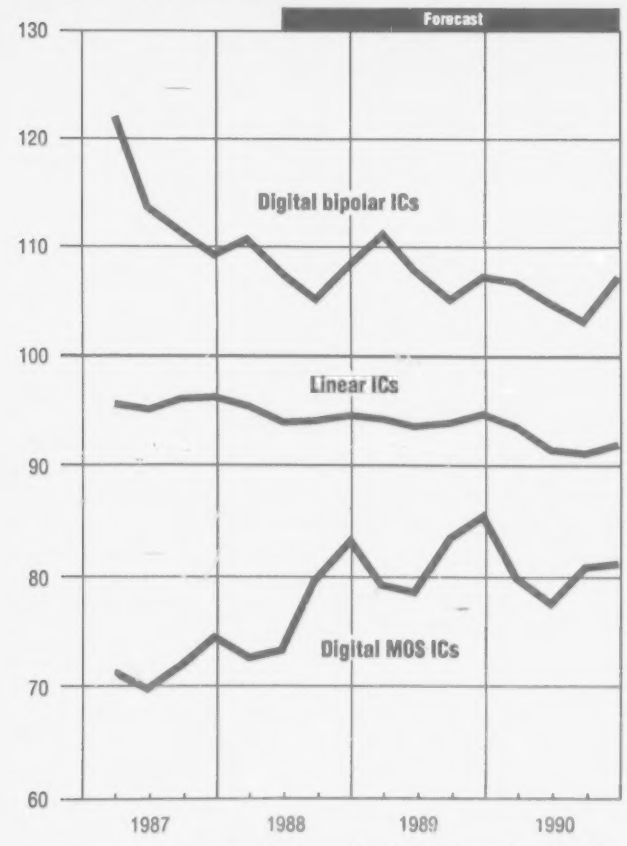


SIC 36

Historical data: Bureau of Labor Statistics; Forecast: Cahners Economics

Producer price indexes — Active components

Quarterly averages, 1st quarter 1982 = 100



Historical data: Bureau of Labor Statistics; Forecast: Cahners Economics

Capacity utilization rates are at a record high

Capacity utilization of our nation's factories teased the 84% mark in the hot summer months of July and August, a record high for this decade. Particularly hefty increases in capacity utilization rates were recorded in the primary metals and chemicals industries. But the industrial sector has reached its peak for this business cycle, so factory operating rates are heading downward through 1990.

Electrical machinery highest since 1985

In July and August, electrical machinery manufacturers kept plants running at 78.1% of capacity, the highest monthly rate since early 1985. However, industrial output in this industry is expected to slow in 1989 and early 1990. Growth in new orders for electrical machinery started tapering off in July and shipments have been flat for several months.

This letup will take the pressure off any capacity constraints. Operating rates will ease to about 76.7% through the first half of 1990, before renewed production growth kicks in additional gains in capacity utilization.

Instruments rates top 82%

Even with the addition of capacity, factory operating rates in the instruments industry broke through the 82% barrier, recording some of the highest rates in three years. Because the instruments sector is anticipated to sustain slow but steady growth next year, capacity utilization rates are expected to hover around 80% to 81% until late 1989.

Aerospace rates drop

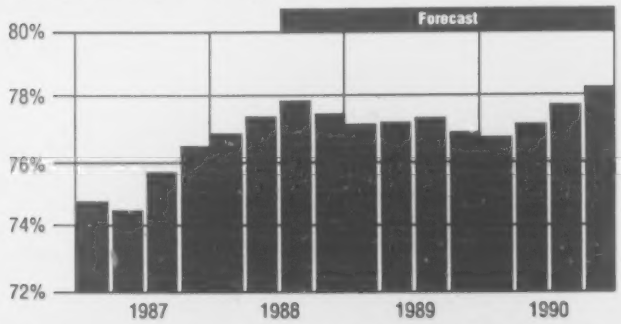
Although the capacity utilization rate in the aerospace and miscellaneous transportation industry bopped up to 87.5% in July, the rate subsided to 86.9% in August and continued its slide that began in March 1987. With defense dollars shrinking in real terms, industrial production of aircraft, ships and military tanks will wane over the next two years. This contraction is expected to shave factory operating rates down to 77% to 78% by the end of the decade.

What is capacity utilization? Each month the Federal Reserve Board estimates production and capacity of our nation's factories, mines and electric and gas utilities. Capacity utilization percentages are calculated as ratios of production to capacity. Capacity estimates are based on a variety of data, such as capacity data in physical units and surveys of capacity growth and utilization rates.

MADELINE FRANCHI

Plant utilization — Electrical machinery

Average percentage of capacity utilized per quarter, seasonally adjusted

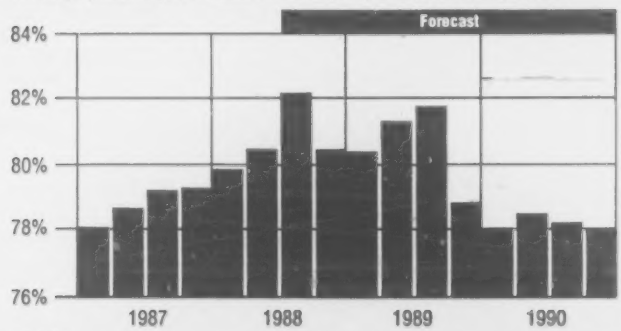


SIC 36

Historical data: Federal Reserve Board; Forecast: Cahners Economics

Plant utilization — Instruments

Average percentage of capacity utilized per quarter, seasonally adjusted

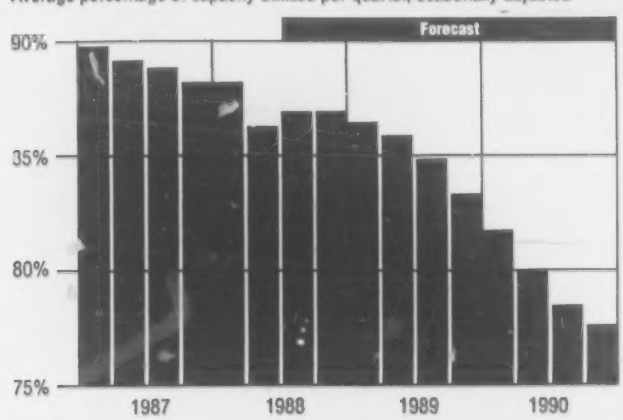


SIC 38

Historical data: Federal Reserve Board; Forecast: Cahners Economics

Plant utilization — Aerospace

Average percentage of capacity utilized per quarter, seasonally adjusted



SIC 37

Historical data: Federal Reserve Board; Forecast: Cahners Economics

IC price pressures are easing . . . finally

After a summer of rapidly rising prices for electronics components, especially for DRAMS (dynamic random-access memories), prices are finally stabilizing. Last summer's inflationary spiral was spotty, with only some components seeing sharp price increases.

According to a monthly survey of buyers made by *Electronics Purchasing*, average selling prices for DRAMS surged from $24 in April to $31 in August. As for 256-kilobit DRAMs, buyers reported average selling prices of $6.25 in August, down from $8.30 the month before and not far off from the $6.50 prices seen last April.

Buyers who were caught without long-term contracts for critical components like DRAMs have no doubt been hardest pressed to handle the summer's hot prices. While the anecdotal evidence has made headlines, on the average, price increases this year have actually been relatively mild.

The numbers behind the headline

For example, using the Bureau of Labor Statistics constant quality producer price indexes, linear integrated circuit prices fell 2.1% in the third quarter, compared with year-ago prices. Digital bipolar prices fell 5.5%. Only digital MOS devices saw a significant price rise, up 10.6%.

Even with quality changes held constant, the Bureau of Labor Statistics estimates that prices for linear ICs and digital bipolar devices grew at a 7% and 29% pace respectively in 1984. That's at the height of the 1984 supply shortages and subsequent price rises. No such dramatic price increases for these composite price indexes have taken place in 1988.

Another statistic that confirms the general boring nature of the 1988 price-supply story: leadtimes. The length of time between placement of an order for electronic components and delivery of that order stretched to a 12-and-a-half-week high in mid-1984. The highest leadtime that electronic component buyers have faced (on average) has been eight-and-a-half weeks so far in 1988.

What's ahead for component prices? Component prices and all industrial commodity prices will probably stabilize even more in 1989, before picking up again in 1990. That's premised on a slowdown in demand in 1989, so producers will be hard pressed to raise prices and buyers will encounter even fewer purchasing headaches next year.

ELIZABETH B. BAATZ